OCTOBER 1956

CEP
CHEMICAL ENGINEERING PROGRESS

new techniques for

ECONOMIC EVALUATION

PATENT STATEMENT

CAPITAL ESTIMATE SHEETS

BACKGROUND

formalize your

APPROPRIATIONS REQUESTS

PLANT OUTLAY

BATTERY LIMITS FACILITIES

EVALUATING WITH INTEREST RATE OF RETURN • COMPARING CAPITALIZED ALTERNATIVES • C.E.P. ROUND TABLE

PLUS: CO_2 Absorption Process • Corn Gluten Filtration • Heat and Radioactive Wastes • Ion Exchange Developments • Boston Meeting Program • O. R. Decision Aiding • How to Recruit

The proof of process equipment....
....is in the *welding* thereof

.... and Vulcan welding is top quality—distinguished by proven skill, modern methods, technical supervision and close inspection (including x-ray). Towers, exchangers, kettles, condensers, piping — all depend on skillful, pressure-tested welds, carefully designed in accordance with your exact process requirements.

This is what you get when you specify Vulcan in your equipment ordering. Vulcan's welding department has gained recognition for its progressive welding methods and proven ability on difficult jobs. Why not obtain these benefits for your company? For quality-built pressure vessels, you can't do better than to order from Vulcan.

We invite your next inquiry.

VULCAN MANUFACTURING DIVISION ®

VULCAN-Cincinnati, Inc. General Offices and Plant, CINCINNATI 2, OHIO

Formerly THE VULCAN COPPER & SUPPLY CO.

BOSTON CHARLOTTE N. C. DENVER HOUSTON SAN FRANCISCO

VICKERS VULCAN PROCESS ENGINEERING CO., LTD., MONTREAL, CANADA

DIVISIONS OF VULCAN, CINCINNATI, INC.

VULCAN ENGINEERING DIVISION • VULCAN MANUFACTURING DIVISION • VULCAN CONSTRUCTION DIVISION

Chemical Engineering Progress

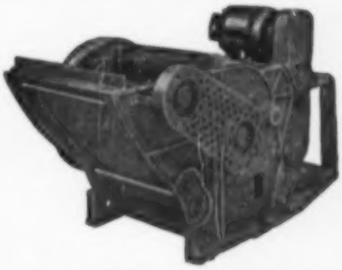
what's in this issue

October, 1956 • Volume 52, No. 10

(Continued on page 5)→

departmental features

Save production time!



DRAVER FEEDERS

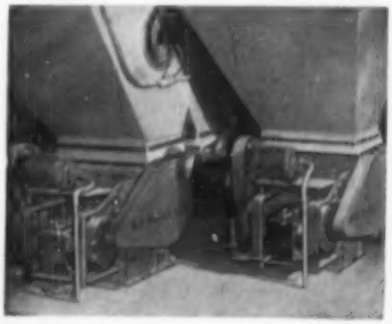
prevent overloading of production units

You can safely operate pulverizers, sifters, mixers, and other production machines at maximum efficiency without danger of overloading, when you control the feed of bulk materials with Draver Feeders. You save power and production time . . . eliminate wasteful reprocessing . . . avoid excessive wear on your equipment.

Capacity adjustment is easy and positive, through speed control of the driving mechanism—thus inlet and outlet openings are wide open at all times. Even stubborn, non-free-flowing products can be fed in a steady, uniform stream.

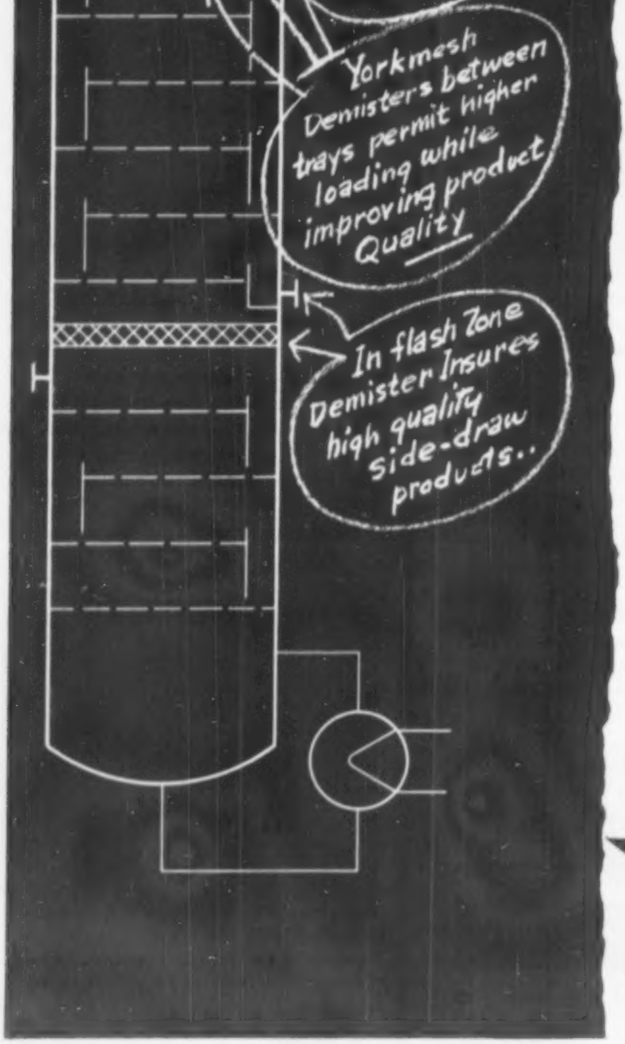
Sturdy, accurate Draver Feeders are made in more than 100 sizes and models, with capacities from minute quantities up to thousands of pounds per hour. There's sure to be a standard model that will save you production time and money. Write for details and recommendations on your specific feeding problem, without obligation.

Draver "Micro-Master" Feeders, mounted at floor level, feed bulk materials to mixing equipment below.



FEEDING • MIXING • SIFTING • WEIGHING • PACKING
PACKAGING EQUIPMENT FOR THE PROCESS INDUSTRIES

B. F. GUMP Co.
—Engineers & Manufacturers Since 1872—
1311 S. Cicero Ave., Chicago 50, Ill.



How to INCREASE THRUPUT in DISTILLATION EQUIPMENT...

The efficiency of separation and thruput capacity of distillation equipment can be significantly improved by the use of YORKMESH DEMISTERS.

Overhead quality is improved by eliminating liquid entrainment containing high boiling impurities.

Increasing thruput in existing equipment often results in decreased product quality. YORKMESH DEMISTERS installed between trays will permit increased thruput capacity while maintaining or improving quality of overhead product.

The advantages of positive separation of liquid from gas are obtained with negligible pressure drop.

Send details on your operating conditions and let YORK engineers take the responsibility of improving the performance of *your* equipment.

Similar improvements in process efficiency are effected by the clean separation of vapor from liquid in:

Vacuum Towers • Flash Tanks
Distillation Equipment • Evaporators
Absorbers • Scrubbers • Steam Drums

WRITE for Bulletin 17 and a complete list of the many case histories available from our technical library.

YORK

OTTO H. YORK COMPANY, INC.
6 Central Avenue, West Orange, N. J.

Specialists in FLUIDS SEPARATION / ENGINEERS and MANUFACTURERS

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Cover design by
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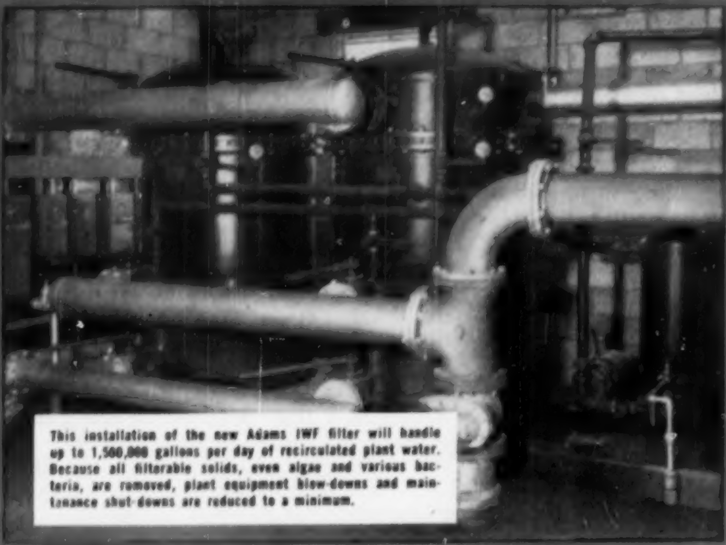
what's in this issue

(Continued from page 3)

Announcing . . .



the NEW ADAMS IWF Industrial Filter

For applications in:

- Process Water
- Coolant Water
- Make-Up Water
- Secondary Recovery
- Boiler Feed
- Bearing Water
- Potable Plant Water
- Waste Water Disposal
- Process Gases

Adams IWF filters are available in a wide range of sizes and multiple combinations. Cleaning is accomplished without disassembly by the unique Adams HI-FLOW backwash design.

The new IWF is only an addition to an extensive line of Adams filters. So, if you have any filtering problem, fill in the coupon below for further information and help.

R. P. ADAMS CO., INC.

240 East Park Drive • Buffalo 17, New York

In Our Twentieth Year of Service to Industry

R. P. ADAMS COMPANY, INC. 0-56

240 East Park Drive, Buffalo 17, N. Y.

We have a filtration problem. Please have your local representative call on us.

Name..Title..........................

Firm...

Street...

City..State.........................

Marginal notes

Chemical Process Industries. 2 ed., R. Norris Shreve, McGraw-Hill Book Company, New York, (1956), 1,004 pages, $11.50.

Reviewed by Frank C. Vilbrandt, Virginia Polytechnic Institute, Blacksburg, Virginia.

This second edition of an authoritative work on chemical industries represents a checking of the literature and of the chemical industries since the first edition appeared in 1945. As in the first edition, the presentation is from the viewpoint of the fundamental chemistry involved, of the energy released, absorbed, or required, and of the economics of the processes and markets; it is replete with up-to-date flow diagrams compiled by the author and by experts in the respective industries.

The contents are presented largely from the teaching viewpoint to integrate various courses, such as physical and organic chemistry, and also to give the chemical engineer some comprehension of the various fields with which he may become affiliated. Incidentally, it is also a reference book for practicing engineers and chemists.

The objectives in the presentations have been given to the various chemical processes in a generalized form through the correlation into flow diagrams and descriptive text on unit processes, unit operations, equilibrium and reaction rates, statistics, markets, energy and power consumption, and materials and operations costs.

This book is necessary reading for every chemical engineer and will be in constant use.

The Condensed Chemical Dictionary, revised and enlarged by Arthur and Elizabeth Rose. Reinhold Publishing Corporation, New York (1956), 1,200 pages, $12.50.

Reviewed by J. B. Calkin, Assistant to President, Foster D. Snell, Inc., New York.

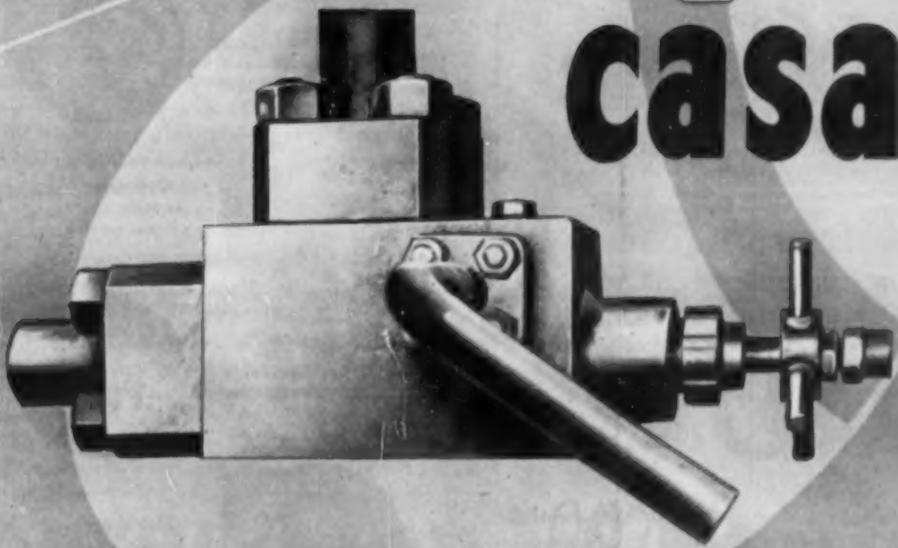
This standard work originally directed by the late Francis M. Turner is now in its fifth edition with 450 additional pages. It contains a numerical list and an alphabetical list of manufacturers; it gives the regulations for the transportation of explosives and other dangerous articles; lists some statutes affecting the labeling of chemical materials including some warnings

(*Continued on page* 11)

for low-cost NH_3

FW

casale



casale ejector eliminates recirculating compressor

Recirculating unconverted synthesis gas from the reactor, this simple ejector, with no moving parts, is one of many reasons for the economy, dependability and easy operation of the Casale process.

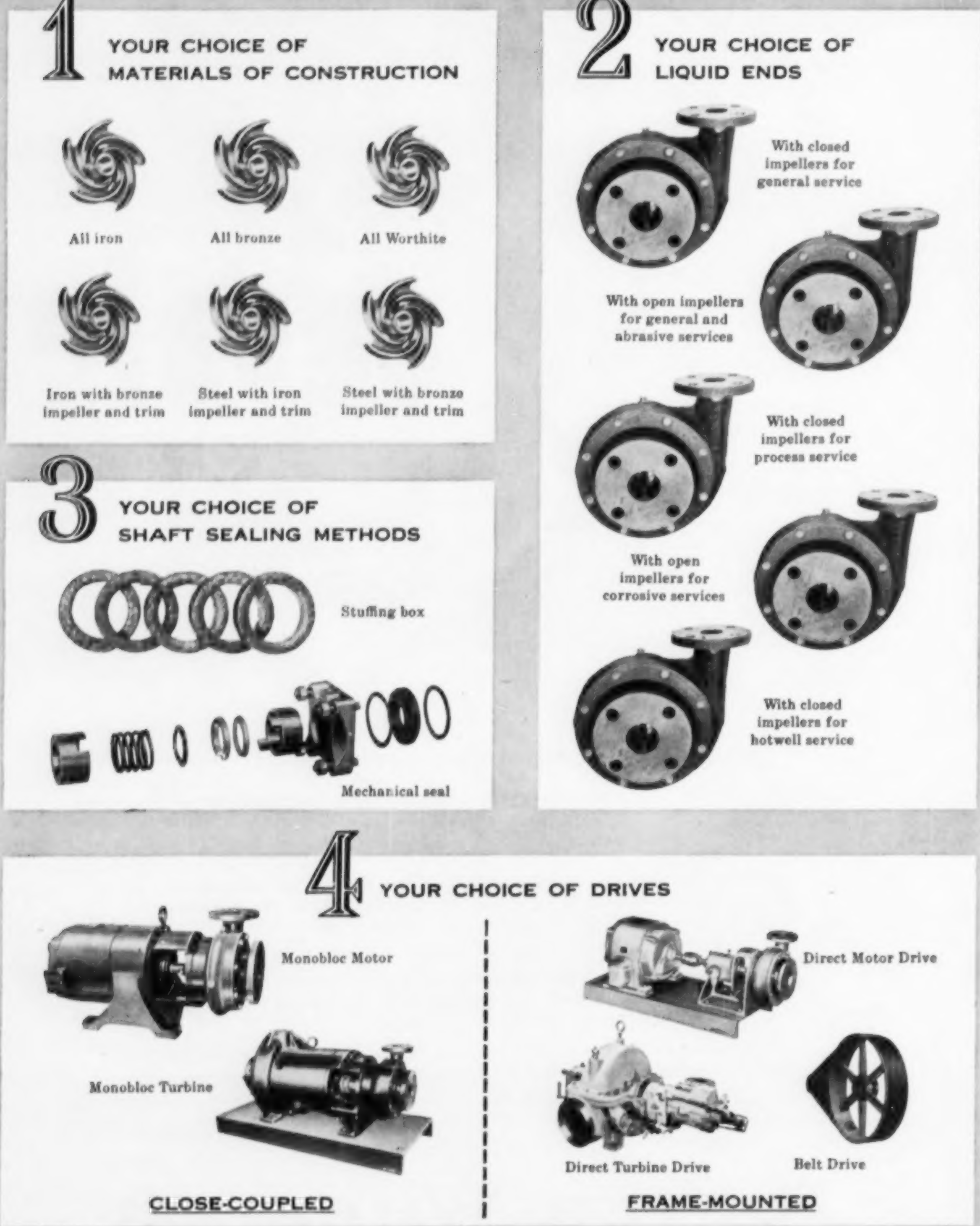
Five Casale plants for low-cost Ammonia synthesis, designed and built by Foster Wheeler, are in operation at higher-than-design capacity; three more FW Casale plants, with a combined capacity of 585 tons per day, are now in the design or construction stage.

For complete information on the cost-saving advantages of the FW Casale process, write for Bulletin 0-54-1. ***Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.***

FOSTER WHEELER

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT.

Pump standardization



Choose from 70,480 combinations. Worthington's SESC—Standard End Suction Centrifugal—line allows you to "custom-build" your pump from stock parts. In each of the 120 sizes, you have a choice of materials of construction, types of liquid ends, shaft sealing methods, and drives. Because the SESC line is built from standard, stocked parts, you get prompt delivery at competitive prices.

slashes inventory, reduces downtime, cuts maintenance

...yet gives you 70,480 combinations to choose from

STANDARDIZE AND SAVE! NOT SOMETIME IN THE FUTURE, BUT NOW!

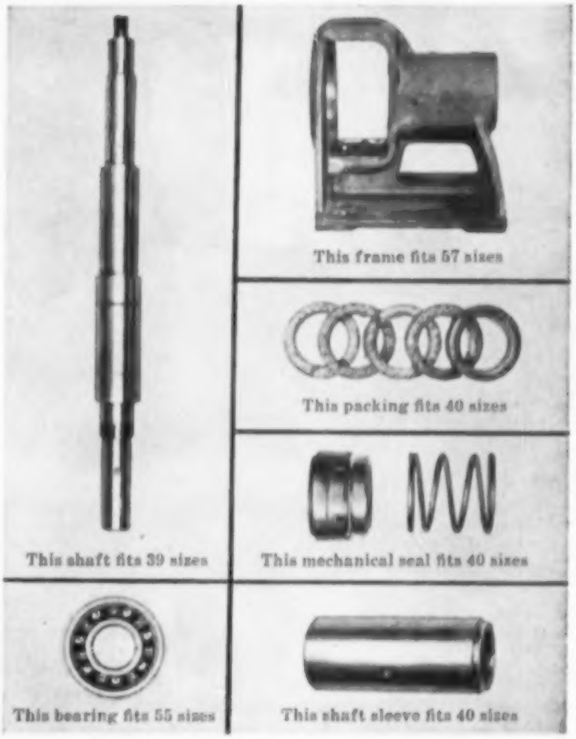
With Worthington's SESC–Standard End Suction Centrifugal–line, you can cut your warehousing and inventory costs as much as 50%, greatly simplify pump maintenance, and reduce downtime.

You get these benefits *without* sacrificing flexibility. In fact, the SESC line gives you an even broader selection. Because *parts* have been standardized and not *pumps* you can literally "custom-build" your pump to get exactly the right features for your particular application.

The complete Worthington SESC pump line consists of six separate types, all suitable for either motor, turbine, or belt drive. Ratings range up to 2700 GPM and 230 ft. head. Pumps and spare parts are available from field stock in all strategic areas as well as from the factory.

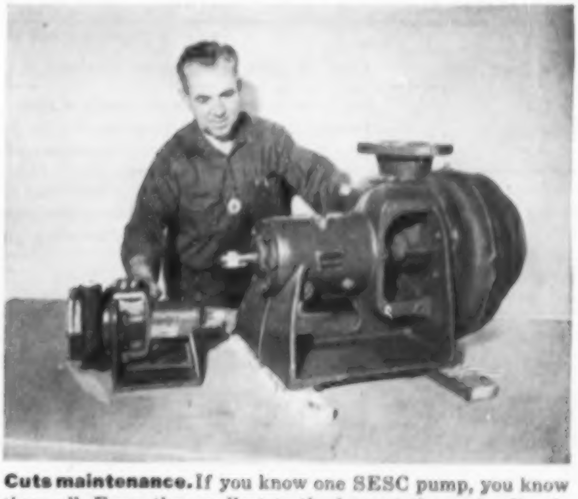
If you'd like to know more about the SESC line, write to Section PC61, Worthington Corporation, Harrison, N.J. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ont. PC6.1

WORTHINGTON



Slashes parts inventory. You can cut inventory costs as much as 50% by standardizing on the SESC–Standard End Suction Centrifugal–line. In the 120 sizes in the complete line, many, many parts are interchangeable. As shown here, one shaft is used in 39 sizes, one bearing in 55 sizes, one frame in 57, one packing in 40, one mechanical seal in 40, and one shaft sleeve in 40 sizes.

Reduces downtime. Parts interchangeability can mean big savings. When repairs or conversions are necessary, standardization can often drastically cut downtime. For example, all SESC pumps can quickly be converted from packed stuffing box to mechanical seal and vice versa using *stock* parts.



Cuts maintenance. If you know one SESC pump, you know them all. From the smallest to the largest the entire line is built to the same basic design. Maintenance men quickly become familiar with construction details. Their work is simplified and maintenance costs greatly reduced.

HIGH CAPACITY CLEAN DISCHARGE WITH EIMCO PAN FILTERS

Detail of Eimco stainless-steel pan-filter showing flexible vacuum and blow connections to each pan. These are exclusive features on the Eimco Pan Filter — particularly advantageous when the slurries filtered require periodic clean-outs of internal parts.

Greater filtering capacity, cleaner discharge and superior washing and drying make the Eimco Pan Filter a highly efficient unit.

Each pan functions as an individual filter with feed, wash, dry and discharge cycles. The pans may be jet washed from the bottom, assuring a clean media during every revolution.

Eimco Pan Filters can be constructed from a wide range of materials to ensure long life and low maintenance when processing corrosive slurries. Materials such as rubber, plastic and many others may be bonded to the surface of the metal construction for protective coating or to prevent product contamination.

Pan filters are available in a variety of sizes from 10 to 500 square feet of filter area.

These and other outstanding features listed below in a comparison with table filters, make the Eimco Pan Filter the most practical and efficient horizontal type vacuum filter available.

	TABLE FILTERS	EIMCO PAN FILTERS
Cake Discharge	Heel of cake remains on media.	Clean, full cake discharge.
Washing	No clear separation of wash. Cake remaining on media carries liquor past cake discharge point, diluting the strong filtrate.	Absolute separation of wash.
Media	Becomes blinded easily. Must stop to remove cake and wash. (Phosphoric acid operation requires considerable downtime.)	Media kept clean through wash during each cycle. Downtime minimum.
Removing, Repairing Media	Difficult repair job.	Media on each pan is easily and quickly changed or repaired.

Let Eimco engineers consult with you on your filtration problem. For years they have made it their business — through research — to offer better liquid-solid separation through filtration.

THE EIMCO CORPORATION

Salt Lake City, Utah—U.S.A. • Export Offices: Eimco Bldg., 52 South St., New York City

New York, N. Y. Chicago, Ill. San Francisco, Calif. El Paso, Tex. Birmingham, Ala. Duluth, Minn. Kellogg, Ida. Baltimore, Md. Pittsburgh, Pa. Seattle, Wash. Pasadena, Calif. Houston, Texas Vancouver, B. C. London, England Gateshead, England Paris, France Milan, Italy Johannesburg, South Africa

B-209

Marginal notes

(*Continued from page 6*)

and safety information; describes many chemicals, specialties, and products which have come to be identified either officially or unofficially by trade-marks, trade names, or brand names.

Thumb-indexed for ready reference and with easy-to-read print, scarcely a subject identified with the chemical field has been omitted—adhesives, antibiotics, ceramics, dyes, engineering materials, medicines, metals, nuclear terminology, petrochemicals, radioisotopes, solvents, synthetic organics, and textiles—in all more than 30,000 revised, up-to-date entries.

Those who have used this "Bible" in the past have evaluated it as a ready reference for use in the chemicals and chemical processing industries. To the newcomer in this field it is highly recommended for general use. It should form a part of a chemical engineer's personal library.

Criteria for Professional Employment of Engineers. Prepared by Engineer-in-Industry Subcommittee of the Employment Practices Committee. National Society of Professional Engineers, 2029 K Street, Northwest, Washington 6, D. C. (1956) 23 pages, 25 cents.

Printed in check-list format, the criteria, suggesting the responsibilities of the employer to his professional employee, and the latter's responsibilities to the employer, cover specific categories of engineering career development. Topics included are recruitment, indoctrination, personnel practices, and termination policies. Part I is expressed in terms of the company's attitudes, policies, etc. Part II covers the same general ground from the standpoint of the engineer's outlook.

Testing of Silicone Rubber at Elevated Temperatures. A. J. DeFrancesco (1956) 41 pages, $1.25.

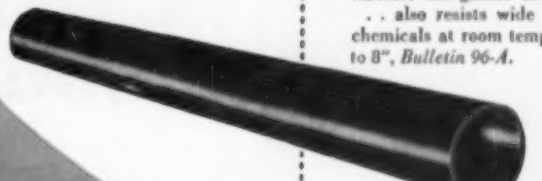
Room - Temperature - Vulcanizing Silicone Adhesive. A. J. DeFrancesco (1956), 69 pages, $1.75.

Two reports of research dealing with silicone rubber—one with its physical properties at high temperatures and the other with the development of rubber-metal adhesives—have been made available through the Office of Technical Services, U. S. Department of Commerce.

(*Noted and Quoted on page 14*)

Only the Right piping can deliver a "GOOD RUN"

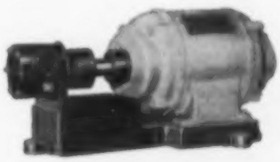
For profitable runs you must keep equipment "on stream" full time with no corrosion shut-downs. Protect your profits with Ace piping, pumps, valves, and tanks. Many rubber and plastic materials . . . backed by a century of chemical experience. Get facts today from American Hard Rubber Company.



FOR HOT CORROSIVES:
ACE TEMPRON

Heat-resistant nitrile hard rubber pipe handles inorganics at 250-275 deg. F. . . . also resists wide range of organic chemicals at room temperature. Sizes 1" to 8", *Bulletin 96-A*.

MIGHTY MIDGET
for pumping acids



Jabsco neoprene-impeller pump made of ACE hard rubber outlasts, out-pumps anything in its pressure, size and price class. Capacity from 15 gpm. at 22 ft. head to 5 gpm. at 72 ft. head. *Bulletin 97-A*.

TOUGH ACE-ITE PLASTIC PIPE

General-purpose moderately priced rubber-plastic pipe handles most common chemicals to 170 deg. F. . . . except few strong acids and organic solvents. Tough, odorless, tasteless. Rigid pipe ½" to 6". *Bulletin 80*.

SENSITIVE, BUT KEEPS YOUR HEAD

ACE Darling Swing Check Valve . . .

lined with ACE hard rubber for the best in corrosion resistance. Large, straight-through flow areas. Sensitive to slight pressure differential. Non-slamming. Sizes 2" to 24". *Bulletin CE-52*.

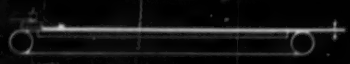
ACE processing equipment of rubber and plastics

AMERICAN HARD RUBBER COMPANY
93 WORTH STREET • NEW YORK 13, N. Y.

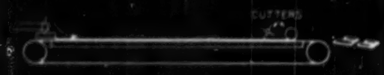
Some of the functions that have been successfully performed by Sandvik Conveyors

WITH A SANDVIK WATER-BED CONVEYOR YOU CAN:

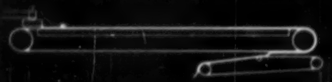
COOL AND CONVEY



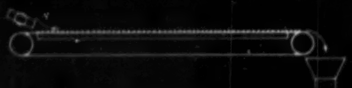
REGULATE THICKNESS WHILE COOLING (ANY THICKNESS UP TO 1" CAN BE COOLED)



CUT MATERIAL TO DESIRED SIZES WHILE COOLING

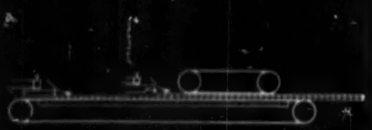


COOL AND STRIP OFF GELATINOUS MATERIALS IN SHEET FORM



COOL LOOSE AND PULVERIZED MATERIALS

COOL SOLIDS IN SHEET FORM

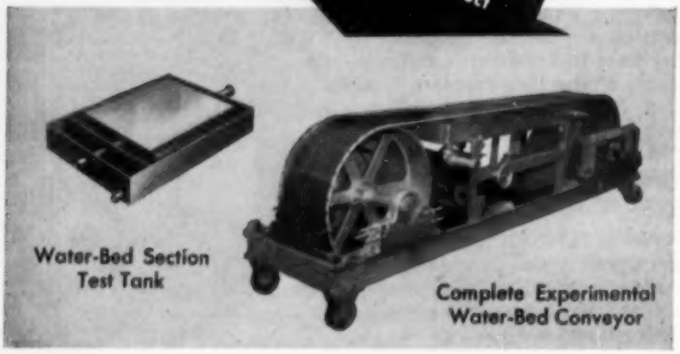


COOL MATERIAL IN LAYERS

HOW CAN SANDVIK'S CONTINUOUS STEEL-BELT COOLER

Improve YOUR production?

HERE ARE TWO WAYS To "Pre-Test" Sandvik's Steel-Belt, Water-Bed Conveyor With Your Own Product



Water-Bed Section Test Tank

Complete Experimental Water-Bed Conveyor

With one of these experimental units you can find out how Sandvik's patented water-bed conveyor can make your processing more automatic.

A small scale trial in your plant will enable you to determine cooling rates and other pertinent data. You will see for yourself the extraordinary cooling capacity of this conveyor combined with the advantages of the steel belt.

How The Water-Bed Conveyor Operates—The loaded steel band "floats" along on an open trough of circulating water. The water pressure assures 100% coolant contact with the belt. The trough is so designed that no water can get on top of the belt.

Experimental water-bed units are available on request. Sandvik's engineering department will help you decide which test unit is best suited for your purpose. Write, wire or 'phone for complete details.

SANDVIK STEEL BELT CONVEYORS
Division of Sandvik Steel, Inc.
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SS-64

DU PONT

Better Things for Better Living
... Through Chemistry

CHEMICAL ENGINEERING NEWS

PROPERTY AND APPLICATION DATA
ON THESE VERSATILE ENGINEERING MATERIALS
"ZYTEL," "ALATHON," "TEFLON," "LUCITE"

Expansion joints of TEFLON® are chemically inert — exceptionally strong

Process lines of ALATHON® are flexible, durable and chemical-resistant

Pipe and process lines of "Alathon" polyethylene resin offer outstanding ease of installation and durability. Process lines of "Alathon" couple quickly without the use of threading — all that is needed is a screwdriver — cutting costs and saving labor. They are lightweight, easy to handle and flexible enough to bend around corners.

"Alathon" demonstrates unusual resistance to chemical reagents. It is substantially unaffected by concentrated hydrochloric, sulfuric, or hydrofluoric acids at room temperature. While permeable to certain organic acids and to some essential oils, it is not altered chemically or mechanically by these materials. The chemical and physical properties of "Alathon" remain unchanged with age, assuring you of long, trouble-free service.

This expansion joint lined with "Teflon" is designed for service at elevated temperatures and pressures. It is inert to all normally encountered industrial chemicals. *(Manufactured by John L. Dore Co., Houston, Texas.)*

Where operating conditions are toughest in the chemical industry, parts of "Teflon" tetrafluoroethylene resin assure dependable operation. Du Pont "Teflon" is not attacked by any chemicals normally encountered—only alkali metals and fluorine under special conditions affect "Teflon." And, conversely, "Teflon" will not contaminate the products in contact with it. The operating temperature range of "Teflon", coupled with its chemical inertness, provides new opportunities for designers of process equipment.

A typical application is the John L. Dore Expansion Joint lined with "Teflon." This joint is designed for service at elevated temperatures and pressures. It features an "L"-shaped steel sleeve imbedded in the flange to prevent distortion. Bolt pressure is transmitted directly to the "Teflon" extending over the flange face, thus assuring a leak-proof seal against the companion flange. The "Teflon" is the only material touched by line commodities.

It will pay you to investigate the possibilities of using "Teflon" in your own application since no other flexible material can serve you so well over such a wide range of conditions.

NEED MORE INFORMATION?

CLIP THE COUPON for additional data on the properties and applications of these Du Pont engineering materials.

"Teflon," "Alathon," "Zytel" and "Lucite" are registered trade-marks of E. I. du Pont de Nemours & Co. (Inc.).

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 7910, Du Pont Building, Wilmington 98, Delaware
In Canada: Du Pont Company of Canada Limited, P.O. Box 660, Montreal, Quebec.

Please send me more information on the Du Pont engineering materials checked: ☐ "Teflon"* tetrafluoroethylene resin; ☐ "Alathon"* polyethylene resin; ☐ "Zytel"* nylon resin; ☐ "Lucite"* acrylic resin. I am interested in evaluating these materials for ______

NAME ______

COMPANY ______ POSITION ______

STREET ______

CITY ______ STATE ______

TYPE OF BUSINESS ______

I-Piece

CHEMICALLY IMPERVIOUS PRESSURE-BALANCED TEFLON BELLOWS DESIGN

Chemiseal Mechanical Seals last longer and give unsurpassed performance under a wide variety of chemical service conditions.

• CHEMISEAL MECHANICAL SEAL

Four years of actual field service, handling acids, alcohols, alkalies, hydrocarbons—clear, abrasive and tarry materials—have proven it.

SEAL ROTATES WITH SHAFT. Only bearing surface is between precision-ground rotating and stationary seal faces. Low friction load and lower power cost.

Rotating seal face is molded as an integral part of the chemically impervious Bellows Unit made of du Pont TEFLON.

NO SCORING OF SHAFTS, and Chemiseals work satisfactorily on shafts previously scored by other seals or packing.

PRESSURES at the seal up to 100 psi at 75°C or 75 psi at 100°C.

SIZES from ⅞" to 2¼". Other sizes on special order.

MAXIMUM LENGTH, all seals 2½".

Ask your U.S. Gasket-Belmont Packing Distributor or write for Bulletin No. MS-1155.

ask your USG BELMONT Distributor

UNITED STATES GASKET CO.
Camden 1, New Jersey

U.S. GASKET • BELMONT PACKING

Noted and quoted

Scientists' Morale in a Security Environment

"It is commonly stated by men of science that freedom is essential to a healthy scientific climate. And yet we hear from members of your group that Russian science, which has surely had to put up with security arrangements more stringent than ours, is in a flourishing condition, and that Russian scientists show evidence of the highest morale in their personal and scientific life. How can this be so?"

—With these words the editor of the Baltimore Sun posed a question of major portent. The question was asked of a recent scientific visitor to Russia, Freeman Dyson, physicist at the Institute for Advanced Study, Princeton, whose answer * is condensed as follows:

First of all, let it be clearly said that Russian physics is not yet as good as American physics. We were amazed at their work, not because it is so wonderful in itself, but because it has improved so much so fact. . . .

Today . . . the Russians know how to make scientific equipment equal in quantity and quality to any in the world, and they have plenty of people who know how to use it. . . . [Yet,] what they have done with their equipment is not . . . so exciting.

The second main fact which we established beyond doubt was . . . [that] a reasonable scientific freedom does now exist. That is to say, Russian physicists enjoy the basic professional freedoms, to work on problems of their own choosing, to publish their results, and to discuss their ideas with foreign colleagues. *These freedoms are restricted by security rules which are similar to ours, perhaps slightly stricter.* (Editor's italics)

The freedom of Russian science is quite new. It came suddenly, soon after the death of Stalin. . . . Two years ago, the whole atmosphere changed. People poured back from the military projects into pure science, publication was encouraged, and international meetings allowed.

All this had an intoxicating effect on Russian scientists. Suddenly to be given these freedoms, which they had not known for 15 years, filled them with optimism and self-confidence for the fu-

* Condensed from *Science*, where the article appeared by permission from the *Sun*, Baltimore, June 26, 1956.

(*Continued on page 24*)

INTALOX SADDLE PACKING

In the five years since Intalox saddle packing was first presented to chemical engineers as a uniquely new and different tower filling material, it has earned widespread acceptance.

Its better HTU values has permitted reduced tower heights resulting in savings in construction costs; its lower pressure drop has permitted savings in initial investment in blowers and pumps and substantial reduction in operating costs; its higher flooding limits have permitted higher liquid and gas rates.

This improved performance stems from the unique, patented shape of Intalox — a shape which makes possible maximum contact area between liquid and gas with minimum resistance to gas flow. A comparison of published data shows that size for size, Intalox offers: a greater number of pieces per cubic foot, a greater total surface area per cubic foot, a higher percentage of free space and less weight. Of even more importance than the greater physical surface area offered by Intalox is the fact that virtually all of the greater area is *accessible* surface area. For no two pieces of Intalox can "nest" to render ineffective any significant portion of the packing.

Intalox saddle packing is manufactured in white chemical porcelain and in chemical stoneware. It is made in six nominal sizes: ¼", ½", ¾", 1", 1½" and 2". Full technical data is given in Bulletin S-29, free on request.

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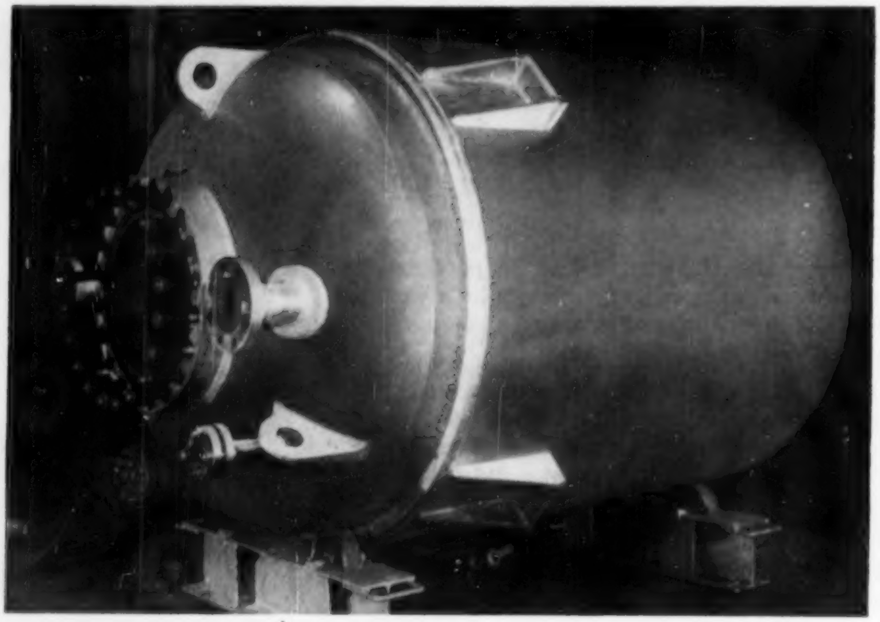

◄ *agitator* ▲ *autoclave*

This steel reaction vessel, complete with agitator and drive, was designed and built by Bethlehem to meet the user's highly specialized needs. The manufacturer wanted a vessel that would require less maintenance and that would be subject to fewer shut downs.

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A heavy duty gear reducer, with minimum bearing runout, drives the agitator shaft. Replacement or adjustment of bearing is made without lengthy shutdowns and expensive repairs.

Downtime from cracking and shattering of agitator impeller, due to embrittlement, has been avoided by use of properly selected alloy steels.

In addition to reduced maintenance and fewer shutdowns, the first cost of the kettle was actually reduced by taking full advantage of up-to-date design features and fabricating techniques.

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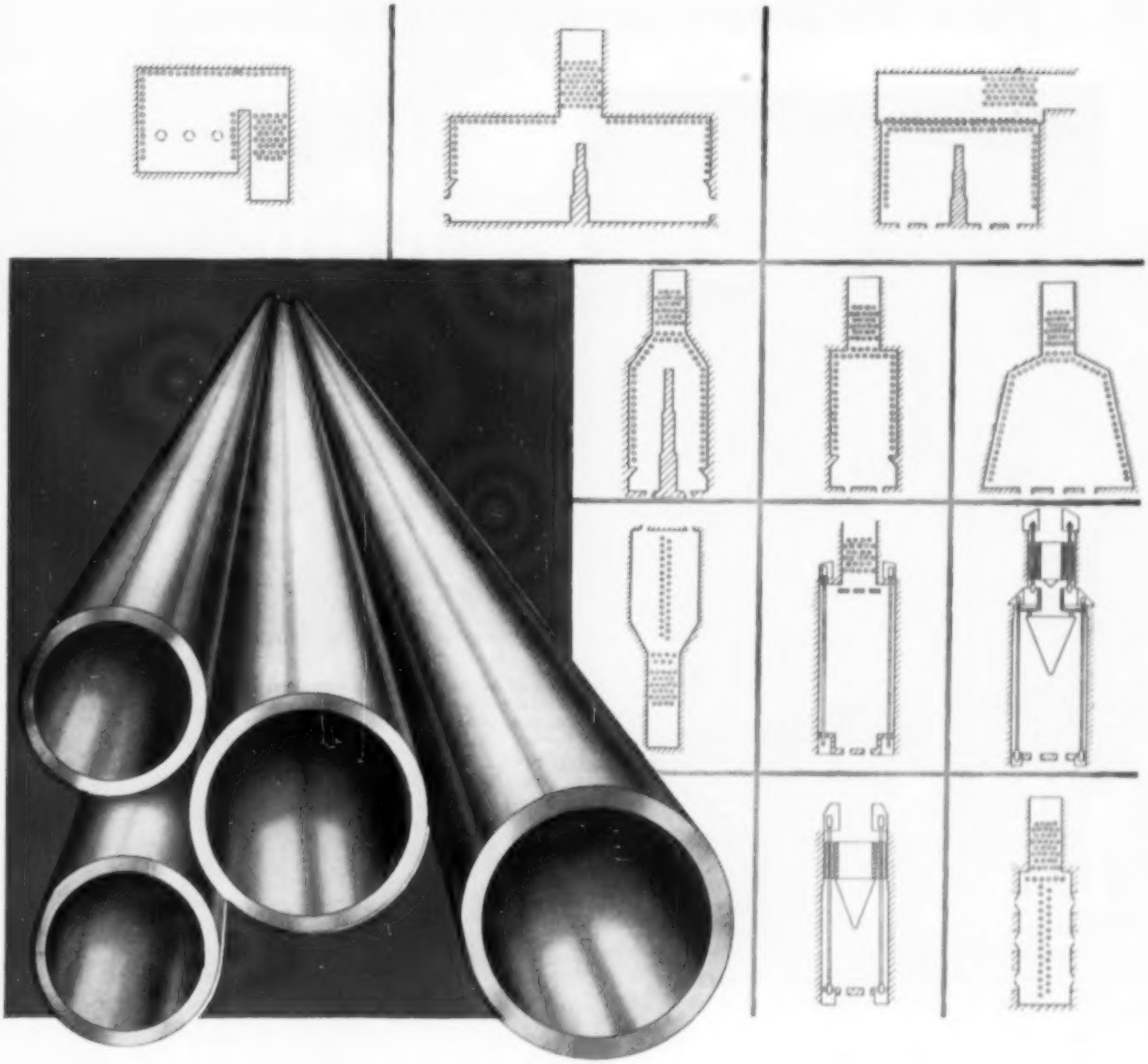

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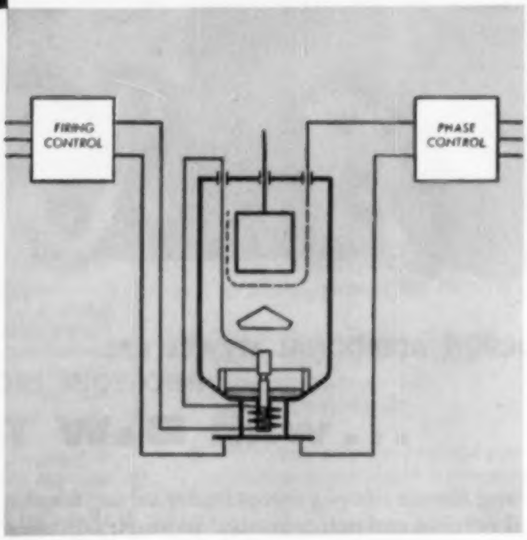

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for these two all-important functions. Improved operation results — one function is never sacrificed for the other — you get optimum operation from each.

For Complete Information on rectifier operation, call your nearby A-C office, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

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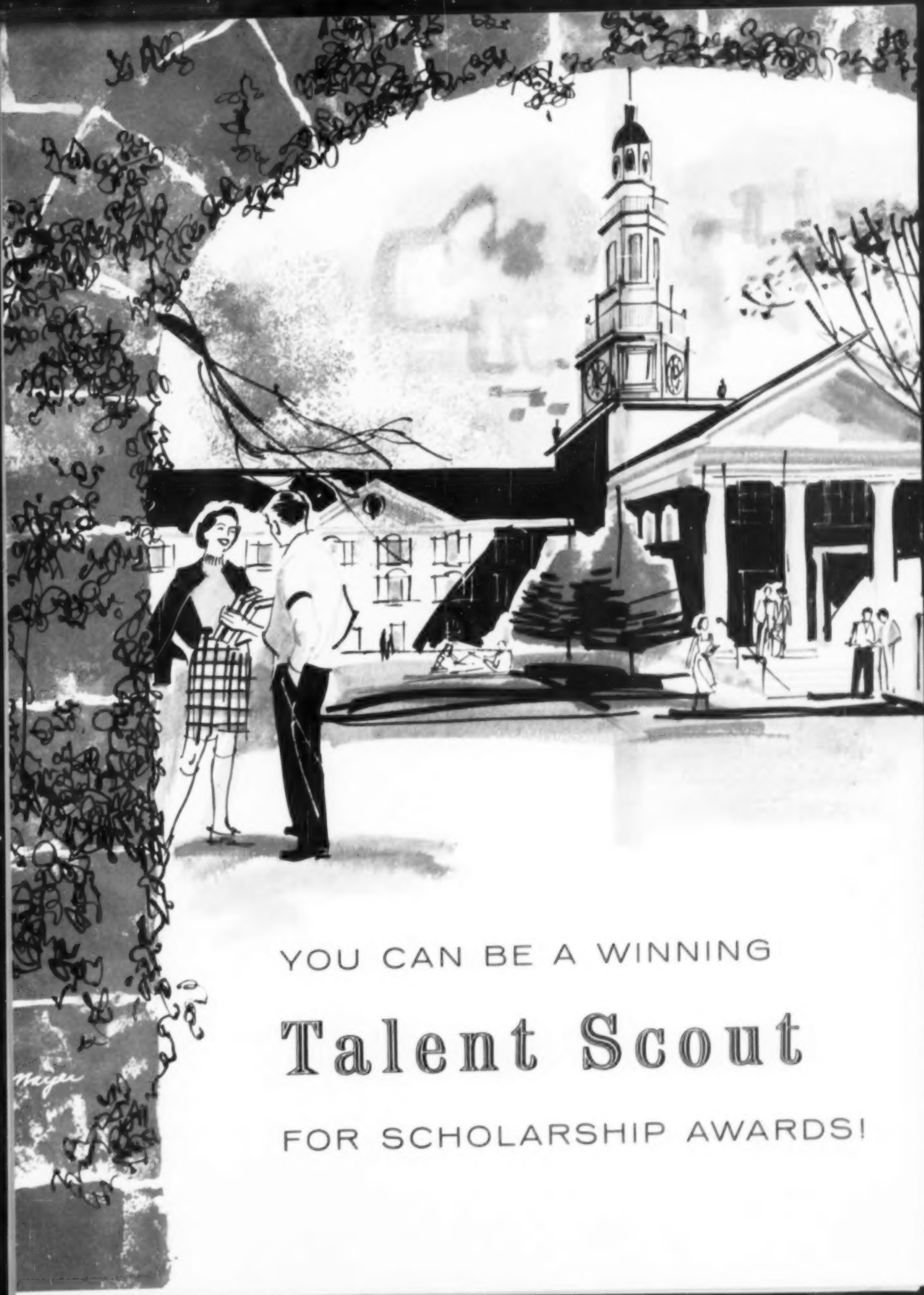
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FOR SCHOLARSHIP AWARDS!

Victor's Talent Scout Contest

4

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We recognize that the cost of a college education prevents some of the nation's talented high school graduates from pursuing their chosen fields in the sciences. This is a great loss to the nation and endangers our security.

Undoubtedly, many of you would like to be helpful and make it possible for some deserving young person to be selected for a four-year scholarship in science or engineering. Perhaps you know of several right now!

Victor is happy to make a modest contribution to help relieve this critical condition, and we are confident you will enjoy participating in this unusual opportunity to nominate someone of your choice.

Yours very truly,

Rothe Weigel

VICTOR CHEMICAL WORKS
Rothe Weigel
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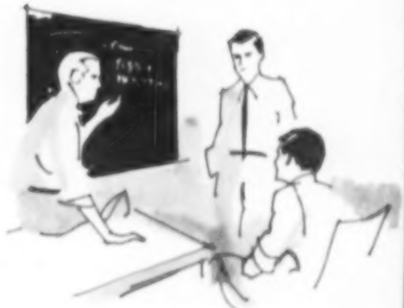
Four, $4,000.00, 4-Year Science or Engineering Scholarship Awards!



You can nominate a high school graduate of your choice!

If yours is one of the 20 winning entries, some fortunate, deserving high school graduate can become your nominee and eligible for a $4,000.00, 4-year Victor scholarship award.

If you send in a winning entry, you may nominate any 1957 high school graduate you wish. It may be your son, daughter, a relative or friend.

It's easy to win!

Write, in a one-page letter (not over 500 words), the kind of a program you think industry should adopt to stimulate the interest of high school graduates in becoming scientists or engineers.

Within a few minutes, you can probably think of several ideas which could be adopted by industry to help solve this acute problem. Just write a page letter giving your ideas for a program. Remember, writing ability is *not* necessary to win. Originality will count most in the final judging. That's all there is to do.

The 20 winning entries will have the honor of nominating a 1957 high school graduate of their choice, according to the rules sent at the time winning entries are selected.

Here's an opportunity for you to help maintain and strengthen the great American heritage of scientific and engineering leadership—possible only if each of us, in our individual way, does something to encourage the nation's talented young people. It's a chance for *you* to be a talent scout for the scientific and engineering leaders of tomorrow!

Each of the 20 winning entries will also receive a personalized, genuine leather attaché case.

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See next page for contest rules and official entry blank

Here's all you do . . .

Write, in a one-page letter (not over 500 words), the kind of a program you think industry should adopt to stimulate the interest of high school graduates in becoming scientists or engineers.

CONTEST RULES

1 All entries will be based upon originality and the basic ideas presented. Writing ability is *not* necessary to win. All entries should be typed and must be accompanied by a properly filled-out Official Entry Blank.

2 All residents of the continental United States are eligible to enter, except students, employees of Victor Chemical Works, their families, or members of their advertising agency.

3 Each contestant may enter the contest one time only.

4 Entries will be judged by The Reuben H. Donnelley Corporation. The decision of the judges will be final. In case of ties, duplicate prizes will be awarded. All entries and ideas presented become the property of Victor Chemical Works.

5 Contest closes midnight, November 30, 1956. All entries must be postmarked not later than that date and received not later than December 14, 1956. Entries must be mailed First Class to: Victor Talent Scout Contest, P. O. Box 5767, Chicago 77, Illinois.

6 Winners will be notified no later than March 1, 1957.

7 If you are one of the 20 winners, you will earn the right to nominate a 1957 high school graduate of your choice for a 4-year, $4,000.00 scholarship in science or engineering.

8 Of the 20 graduates nominated, 4 will be elected for 4-year scholarships.

9 The 4 winning nominees will be selected by a committee appointed by the American Chemical Society. Nominees will be eligible on the basis of rules sent at the time the winning entries are selected.

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VICTOR TALENT SCOUT CONTEST

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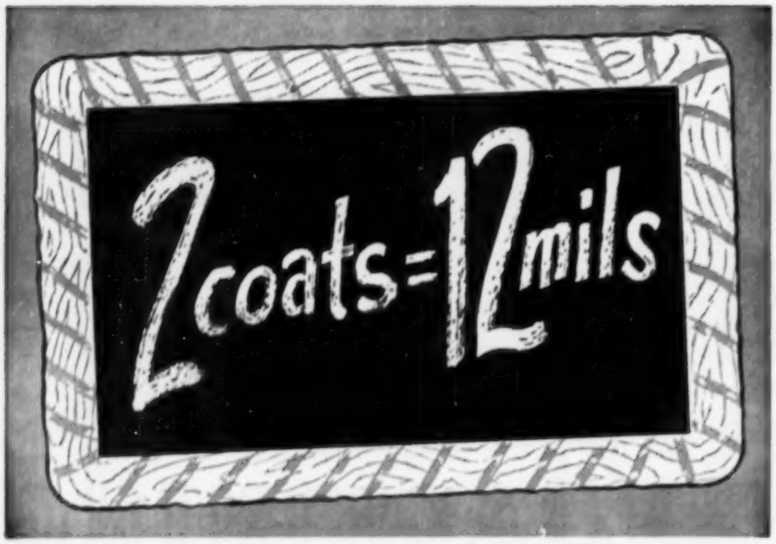

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Noted and quoted

(*Continued from page* 14)

ture. All the time we were in Russia, we could feel how happy they were to be allowed to talk to us. Their enthusiasm and high morale are directly caused by their new experience of freedom. . . .

The good experimental work which has been done in Russia was done after the new regime began. We found clear evidence that the different laboratories in Moscow had been isolated from each other during the earlier time, and that this had hampered their work. . . .

It is clear that the Soviet Government now understands the fact, which the American Government always knew, that scientific progress demands scientific freedom. It is also clear that the Soviet Government is spending enormous amounts of money on pure science, and seriously intends to make Moscow the scientific capital of the world. They have understood that the power of American science depends on America freely and openly attracting people and ideas from all over the world. And they intend now to beat us at our own game.

. . . .

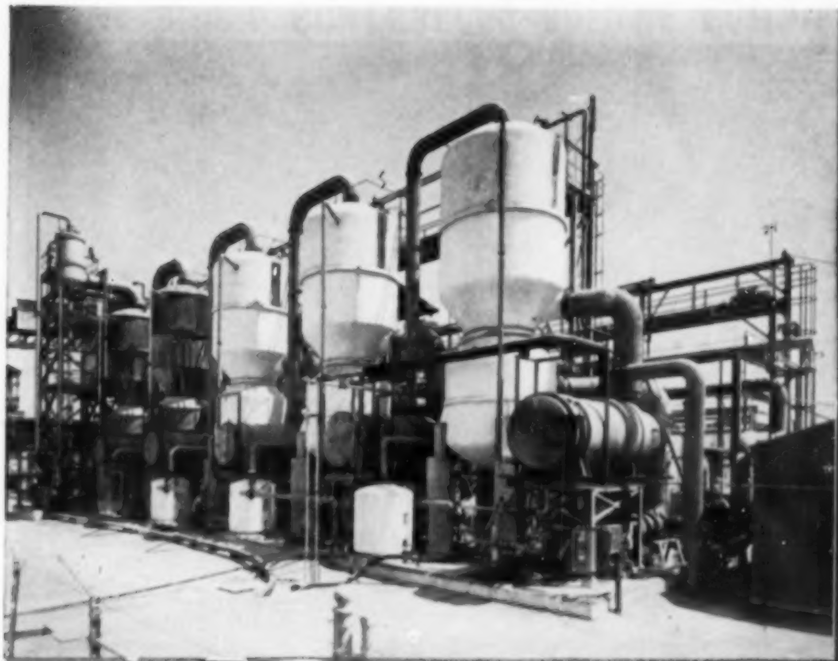
. . . The ordinary Russian people have an understanding of the value and importance of pure science. And they understand and take pride in the fact that learned foreigners come to their country to exchange ideas. It is the atmosphere of public understanding which makes the prospects for the future of science in Russia look so bright. Their scientists have a professional freedom which is not much less than ours, and they have a public support which is in some ways much greater. . . .

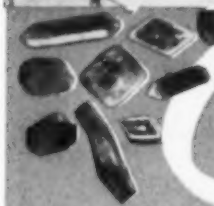
Condensed from "Science"

Basic Attitudes

What are some of the basic attitudes that supervisors have toward their people? First of these might be called statesmanship. The supervisor's philosophy in this case is that the other fellow is capable of being more than he is, and that it is the supervisor's responsibility to help develop . . . his people to their fullest potential. This philosophy is fertile ground for the growth of some . . . other characteristics . . . such as integrity, courage, fairness. A second attitude might be termed trusteeship, or "that for which I am responsible is not mine. I am developing and administering it for the benefit of others." The third attitude is participation or "the other fellow has something to contribute to my efforts and can help me." This type of supervisor, when he delegates authority, does not always in-

(*Continued on page* 28)





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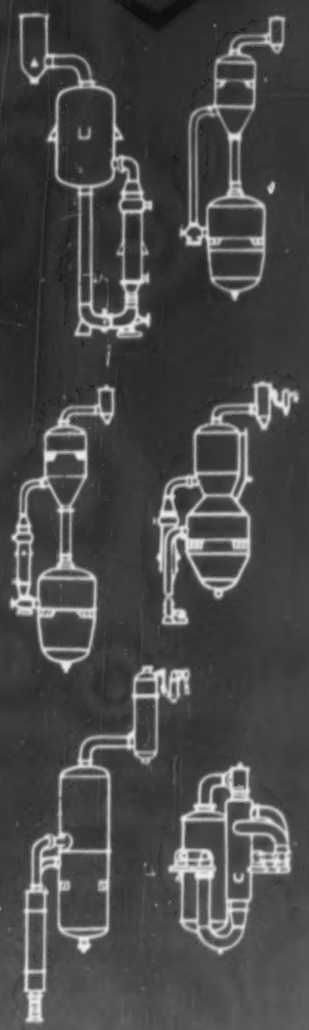

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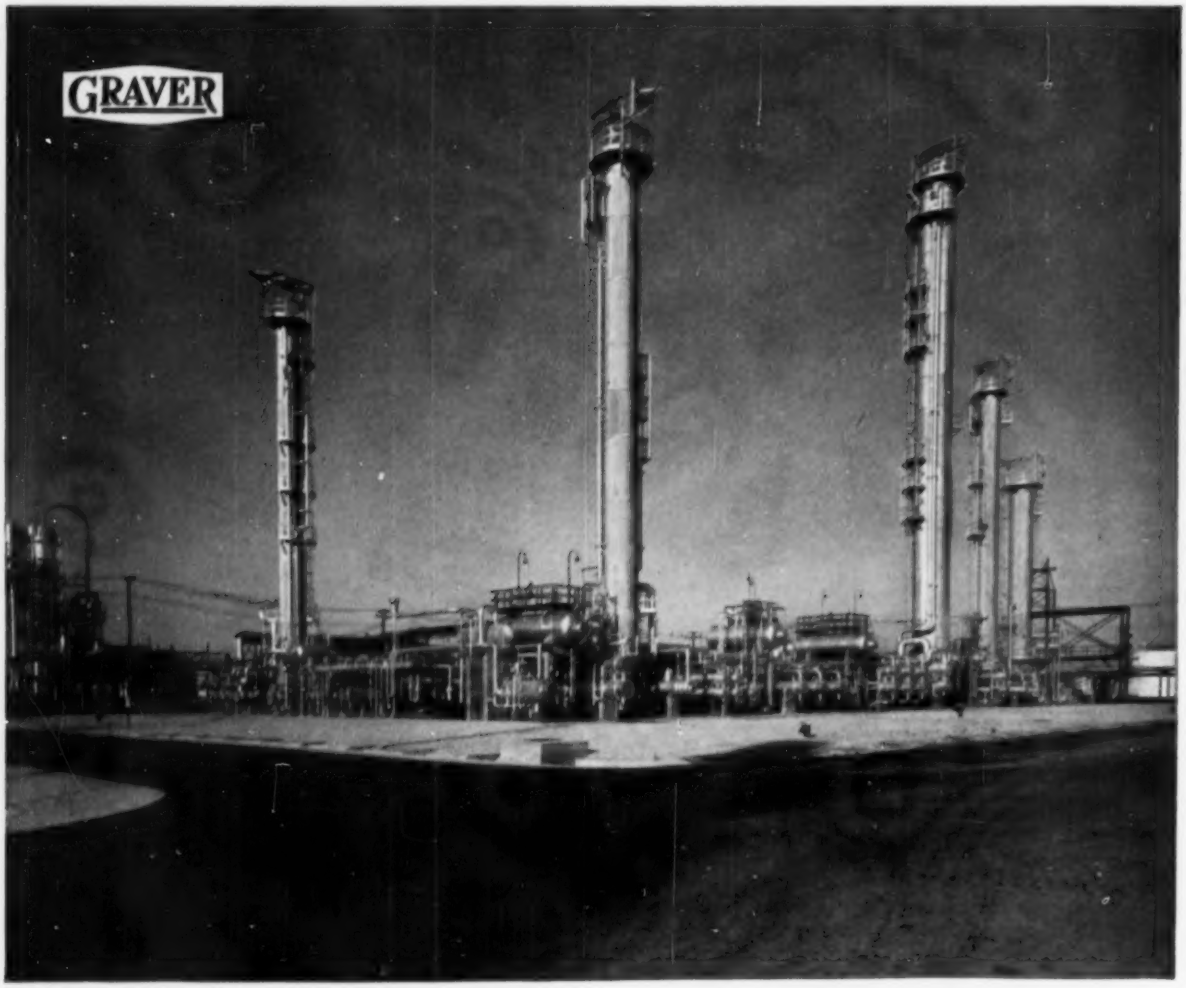

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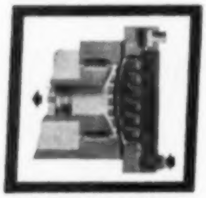
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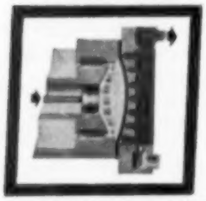
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WRITE FOR BULLETIN 440 *with typical applications, flow charts, description and specifications of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Division, 690 Wilson Street, Le Roy, N. Y.*

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District Engineers in Principal Cities of United States and Canada

Noted and quoted

(Continued from page 24)

sist that subordinates do things his own way. In so doing, he often has occasion to learn something from his subordinates.

The fourth attitude is paternalism or "the other fellow should be cared for and I will decide to what extent." Obviously, we are now getting down into the category of the supervisor who frustrates his men. The next attitude is welfare, or the other fellow should be helped up when down without too much concern for what got him down. Obviously, this supervisor, among other things, does not possess the compassion which makes him genuinely interested in knowing the problems of his men. A sixth attitude might be termed servitude or "the other fellow is to be conquered" or "the other fellow is to serve me for consideration and ask no more."

John Procopi
Excerpted from paper "Leader . . . or Boss?"

Water's Reuse—A Necessity

It is encouraging, at least, to note that almost 40 per cent of the plants studied by the National Association of Manufacturers in 1950 recorded a reuse of water as high as 24 per cent of the intake. The petroleum industry reuses 98 per cent; pulp and paper, 52 per cent; drugs and chemicals, 35 per cent; aircraft, automobiles, and iron and steel, 25 per cent. This practice must continue as the nation's water needs increase.

Industrial Bulletin of Arthur D. Little, Inc.

New Atomic Research Centre

Construction has started near Warsaw in Poland on a centre for atomic research. The centre will include an atomic reactor, and nuclear physics and radio-chemistry laboratories.

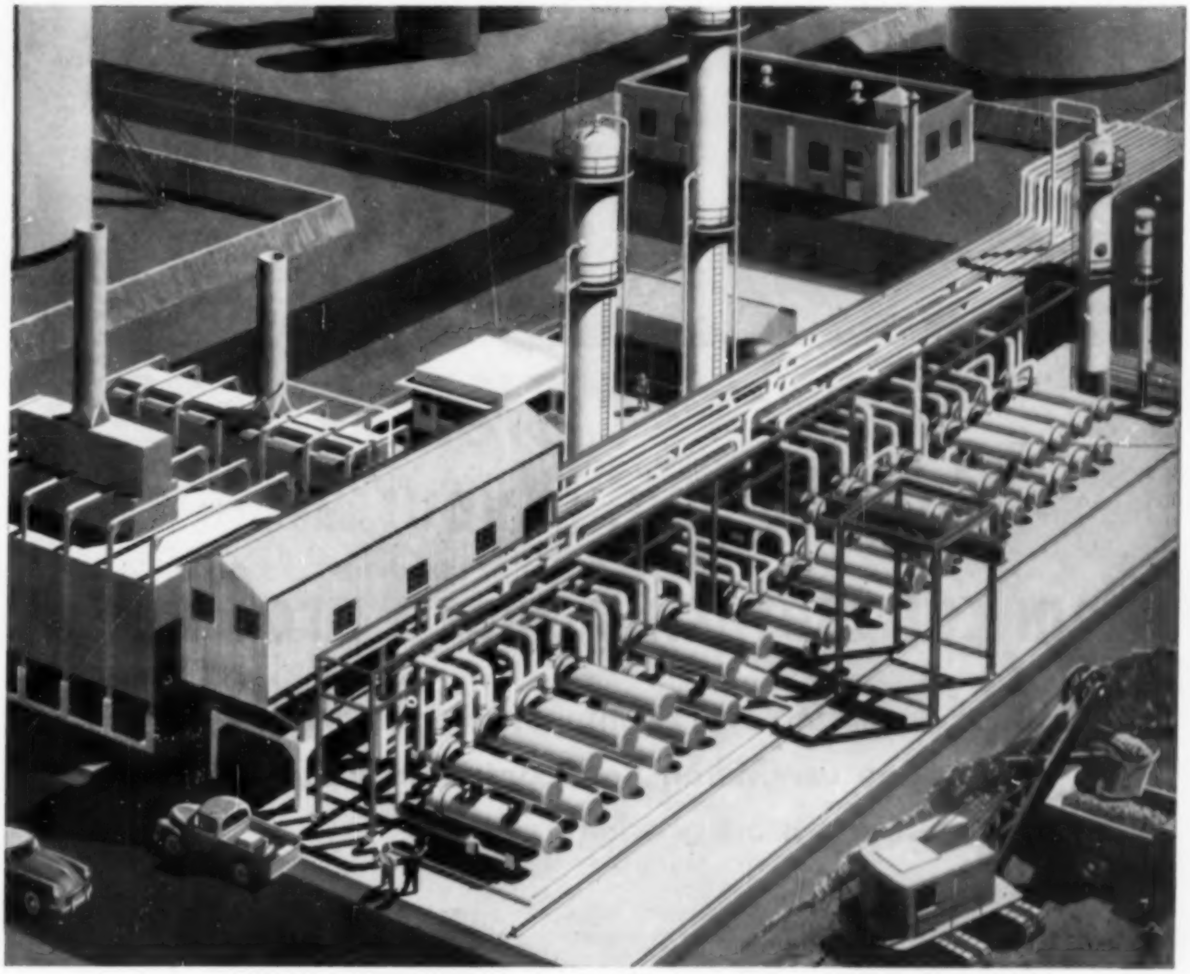
UNESCO

Engineer-Scientist Scientist-Engineer

The modern engineer must become more of a scientist and the modern scientist is being forced to become more of an engineer. . . . The distinguishing characteristics of the two fields are rapidly becoming obliterated and we certainly do have many instances of scientific engineers as well as engineering scientists.

D. H. Loughridge
Speech at General Motors Conference for Engineering Educators

(Letters to the Editor on page 32)



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Blaw-Knox is designing and constructing two Catformers and Unifiners for THE ATLANTIC REFINING COMPANY. One to be installed in their Philadelphia refinery, the other for Atreco, Texas.

The units are identical, each having a reforming capacity of 15,000 barrels per day.

To save both construction time and costs, this project was planned to take advantage of the engineering work for the first unit by adapting it directly to the second installation.

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50th Anniversary BLAW-KNOX 1906-1956

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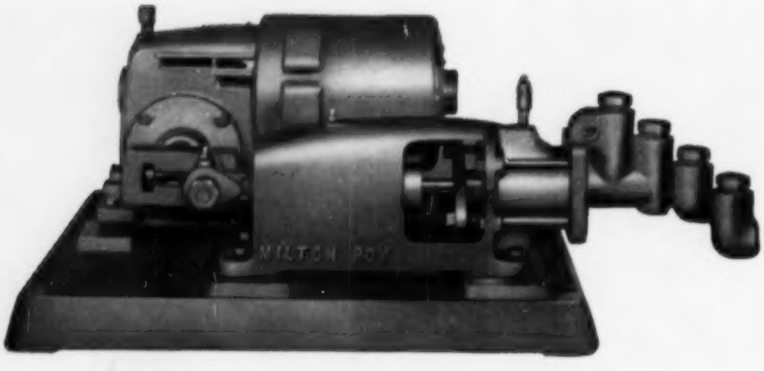

Standard Milton Roy Motor-Driven Controlled Volume Pump.

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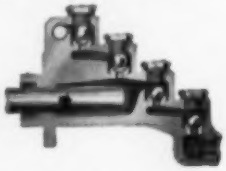

Double ball checks, sloping passages and absence of air pockets assure highest possible volumetric efficiency. Should a solid particle lodge under one suction ball, for example, second suction ball will seat on discharge stroke, thereby preventing fluid from being pumped into suction piping.

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Design and construction dependability provide long service life with minimum maintenance. The result . . . lower production costs, more profitable operation.

Milton Roy Controlled Volume Pumps serve equally well as flow controllers, ratio controllers, or final control elements . . . are available in simplex, duplex, and multiple liquid end types.

Whatever your chemical metering problem or requirement, a Milton Roy Controlled Volume Pump or Chemical Feed System will provide a trouble-free, economical solution. Capacities range from 3 milliliters per hour to 45 gpm . . . at pressures to 50,000 psi.

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By eliminating release of air pollutants
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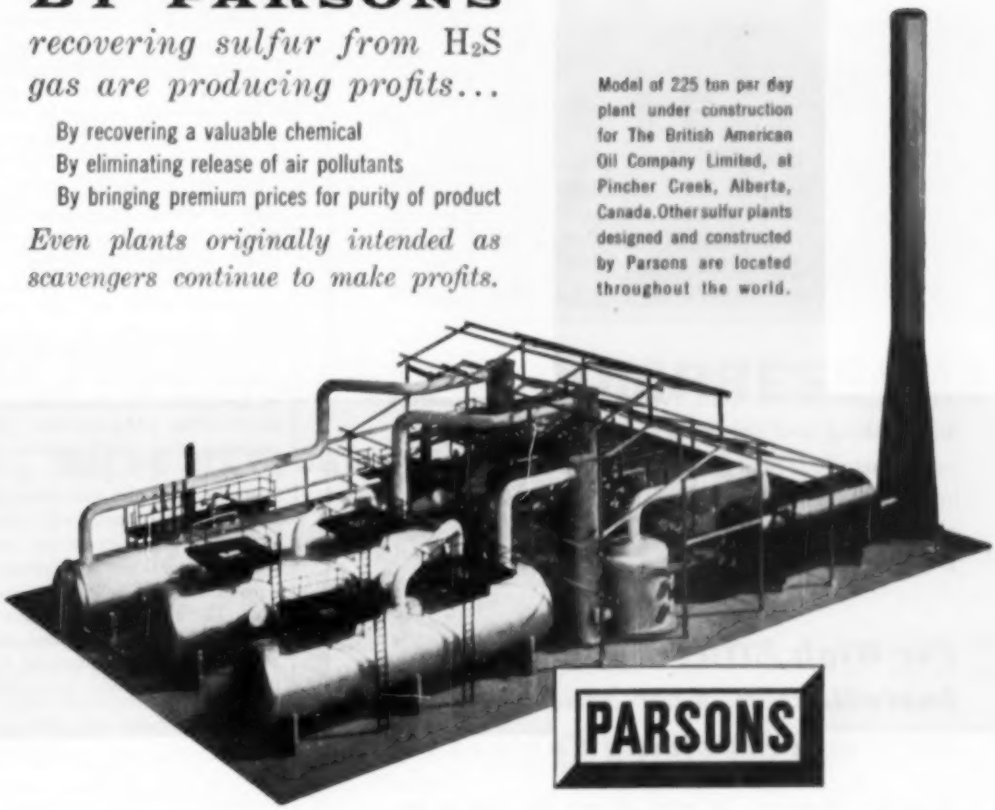
Even plants originally intended as scavengers continue to make profits.

Model of 225 ton per day plant under construction for The British American Oil Company Limited, at Pincher Creek, Alberta, Canada. Other sulfur plants designed and constructed by Parsons are located throughout the world.



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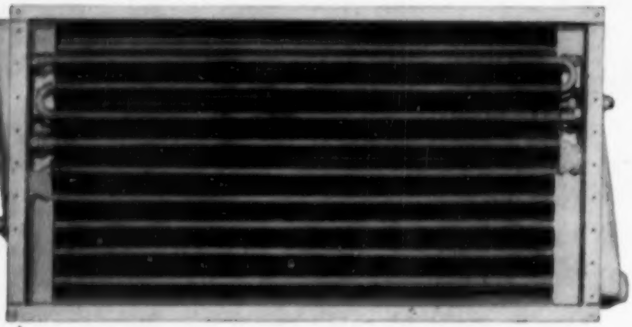

The pioneer in the field, Aerofin has concentrated on one thing, *and one thing only* — highly efficient, easily installed, easily maintained extended-surface heat exchangers. Aerofin's design, research, engineering and production experience and facilities are unequalled anywhere.

For High Efficiency, Easy Installation, Low Maintenance and Servicing Costs . . .

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Letters to the editor

Editor's Note: For a commentary on Mr. Soderberg's views, we have asked the chairman of the Professional Development Committee of A.I.Ch.E. We expect to print his comments next month.

E.J.C. Employment Standards

I was very pleased to read the report by the Engineers Joint Council on Professional Standards and Employment Conditions that you published in the May 1956 issue of *Chemical Engineering Progress*. You are to be complimented on publishing this fine report. It presents a well-thought-out analysis of the Engineer and his status as a professional. Differences between engineers and other professionals are well pointed out. Engineers, management, engineering societies, and engineering educators would do well by studying this detailed report and heeding its recommendations.

One thing was neglected in this report, however. It fails to integrate the professional associations (sometimes called professional unions) into the scheme for advancing professionalism. It fails to recognize that such professional associations are concerned with more than just economic advances; that they are, and should be, concerned with all conditions of employment including professional advancement. The report concedes that, with existent laws and the desire of engineers to dissociate from the craft and industrial unions, the professional unions will continue to grow. It therefore seems logical that these associations will become an important force in advancing professionalism. The report ignores this potential. I believe that professional associations such as ours will continue to advance the engineer's status as a professional

Whiting, Indiana

Peter Soderberg

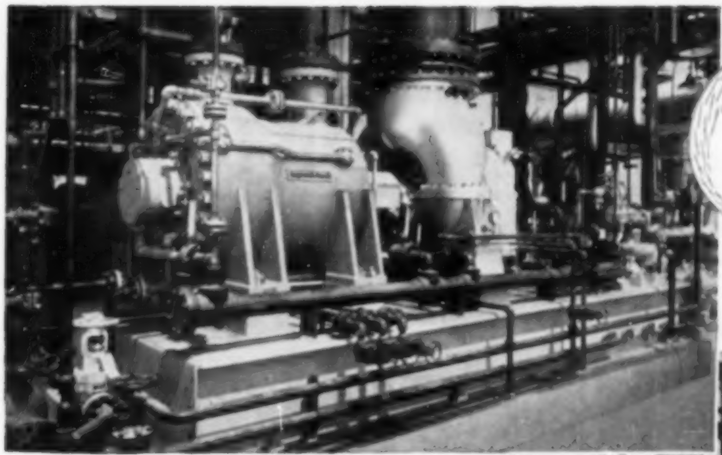
Retention Time in Rotary Dryer

Messrs. Miskell and Marshall state in their paper (*1*): "From Figure 5 it might be argued that the tracer concentration curve does pass through two maxima as proposed by Saeman and Mitchell. However, an inspection of all curves obtained in this investigation led to the conclusion that no more than one maximum can consistently be recognized."

This discussion is submitted to clarify the reference to the work of Saeman and Mitchell (*2*).

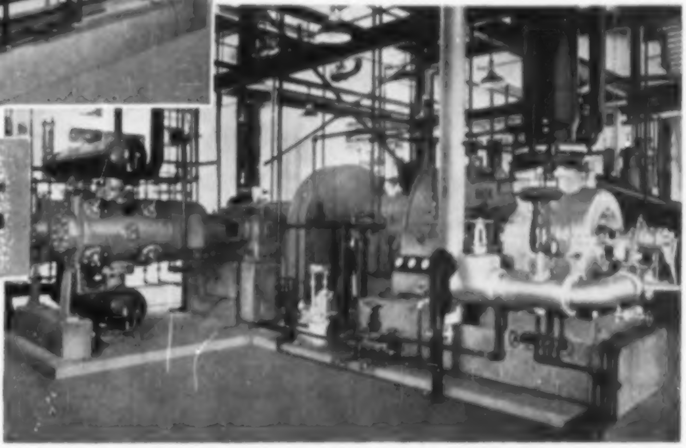
If the cross-sectional dryer loading of Miskell and Marshall's six-flight dryer

(*Continued on page* 36)



Centrifugal

This six-stage I-R Centrifugal Compressor recycles hydrogen-rich gas for the new 17,000 B/D catalytic reformer at Richfield Oil's Watson Refinery. Compressing 102,000,000 cfd from 500 to 670 psig, it is driven by a 2185 hp turbine.



Reciprocating

One of the two Ingersoll-Rand Class HHE Reciprocating Compressors serving desulphurizer unit boosts 59,000,000 cfd recycle gas from 675 to 765 psig. The other HHE compresses 21 million cfd of feed gas from 503 to 765 psig. Both are turbine driven.

BOTH types of I-R COMPRESSORS serve new catalytic reformer at Richfield's Watson Refinery

THE ABOVE installations at Richfield Oil Corporation's newly expanded refinery at Watson, Calif. illustrate an important point. That is Ingersoll-Rand's ability to meet every refinery compression requirement—with whatever type of unit is best suited to actual operating conditions.

The I-R **Centrifugal Compressor** recycles hydrogen-rich gas in the 17,000 B/D reformer. For the reformer's desulphurization unit, two I-R Class HHE **Reciprocating Compressors** are used — one handling hydrogen-rich feed gas, the other on recycle service. See picture captions for compression details.

This new addition to Richfield's Watson Refinery, engineered and constructed by Ralph M. Parsons Co., also uses an Ingersoll-Rand Class ES compressor for catalyst regeneration, an ES-NL unit with non-lubricated cylinders to supply instrument air, and 10 I-R centrifugal pumps for process services.

Whatever your compression requirements, Ingersoll-Rand can supply the equipment *best suited* to the job. With a full line of both centrifugal and reciprocating compressors, I-R recommendations are based solely on the optimum performance and economies of each application. Your Ingersoll-Rand representative will be glad to discuss your compression problems at any time.

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PROCTOR dryers, with Proctor pre-forming and feeding equipment have opened new concepts of expansion for the industry through the years—now recognized the world over for their quality and dependability in rugged service conditions.

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1938	Roller Extruder
1938	Scoring on Filter
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Air Reduction's New Vinyl Acetate Plant On Stream

Engineered and constructed by Lummus, the $3,000,000 facility with capacity of 30 million pounds has smooth start-up; makes 99.99+% pure product.

The new $3,000,000 installation for the production of vinyl acetate monomer has recently gone on stream at Calvert City, Kentucky. Engineered and constructed by The Lummus Company for Air Reduction Chemical Company, a Division of Air Reduction Company, Inc., the unit started up smoothly and was immediately making 99.99+% pure product—even better than specification.

Designed for flexible operation, the 30,000,000 pound per year unit has proved operable in a wide range from ¼ of design capacity to over design capacity.

The plant is of outdoor construction throughout, with process control centralized in a modern control room employing electronic devices. It is located adjacent to Airco's National Carbide Division acetylene generating plant, from which it receives its principal raw material—acetylene. This is converted into vinyl acetate monomer which is, in turn, a basic material for adhesives, latex paints and textile finishes.

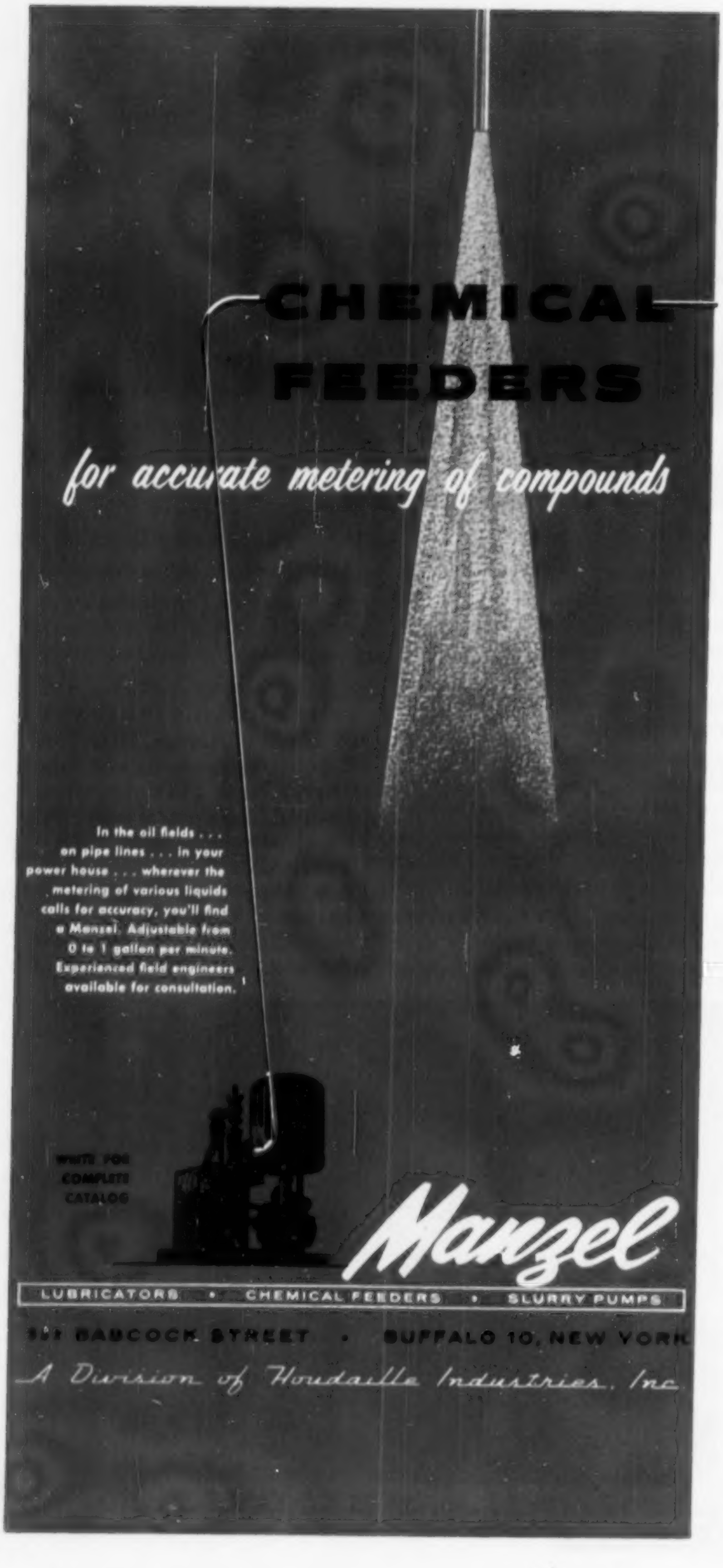
Airco executives who attended the formal opening commended the ability and dispatch with which the Lummus organization carried through the project from inception to completion.

The success of this project is one more indication of Lummus' ability to handle exacting installations for the chemical process industries.

You may find it profitable to look to Lummus for your next plant project.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y. **Engineering and Sales Offices:** New York, Houston, Montreal, London, Paris, The Hague, Bombay. **Sales Offices:** Chicago, Caracas. **Heat Exchanger Plant:** Honesdale, Pennsylvania. **Fabricated Piping Plant:** East Chicago, Indiana. **Engineering Development Center:** Newark, N. J.

Acetylene is purified in unit at left. In larger unit (center), preheated acetylene and acetic acid vapors react to form impure monomer. Distillation towers in this unit purify monomer and recover unreacted acetic acid.



(Continued from page 32)

were analyzed by the method used by Saeman and Mitchell in their derivation of transport time distribution, it will be found that only the first 2.5–3.0% of the dryer load could progress by "flight-action" in the six-flight dryer, compared to more than 10% attained by Saeman and Mitchell using twelve flights of relatively larger capacity. In the case of Miskell and Marshall's experiments, the hold-up in excess of 2.5–3.0% would progress partly by "kiln action." Since transport is in part by kiln action and in part by flight action, the derivation of transport time distribution by analytical methods is considerably more complicated than the analysis of either flight action or kiln action alone.

The deep flights used in the Saeman-Mitchell method of analysis were chosen to yield a mode of transport dominated by flight action to afford a straightforward illustration of the method. The bimodal curve derived from this illustration of the method owes its shape entirely to the choice of a deep-lipped flight. The bimodal effect of this character would not be observed with shallow-lipped flights. Thus, the bimodal shape is not characteristic of the method of analysis, but is due entirely to the choice of operating conditions of the dryer. Other sources of multimodal distributions, such as relative differences in transport rates for kiln action, flight action, rebound of particles from bare metal walls, and air drift in the dryer could also be postulated. In any case, interactions among these modes may well tend to yield less accented peaks on experimental distribution curves than those derived by calculation.

Since Miskell and Marshall used a dryer with shallow-lipped flights and loaded well beyond the limit for simple flight action, the results of their tests are not comparable with the results of analysis reported by Saeman and Mitchell. In view of this difference in operating conditions, no comparison with respect to multimodular characteristics of the transport distribution curves is warranted.

Literature Cited

1. Miskell, F., and W. R. Marshall, Chem. Eng. Progr., **52**, 35-J (1956).
2. Saeman, W. C., and T. R. Mitchell, Chem. Eng. Progr., **50**, 467 (1954).

W. C. Saeman

New York

(About Our Authors on page 43)

Use the Moly key
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High selectivity is provided in reactions where molybdenum catalysts are used. Here are three examples:

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- In the desulfurization of petroleum stocks, the carbon to sulfur bond is selectively hydrogenated with recoveries of almost 100%.

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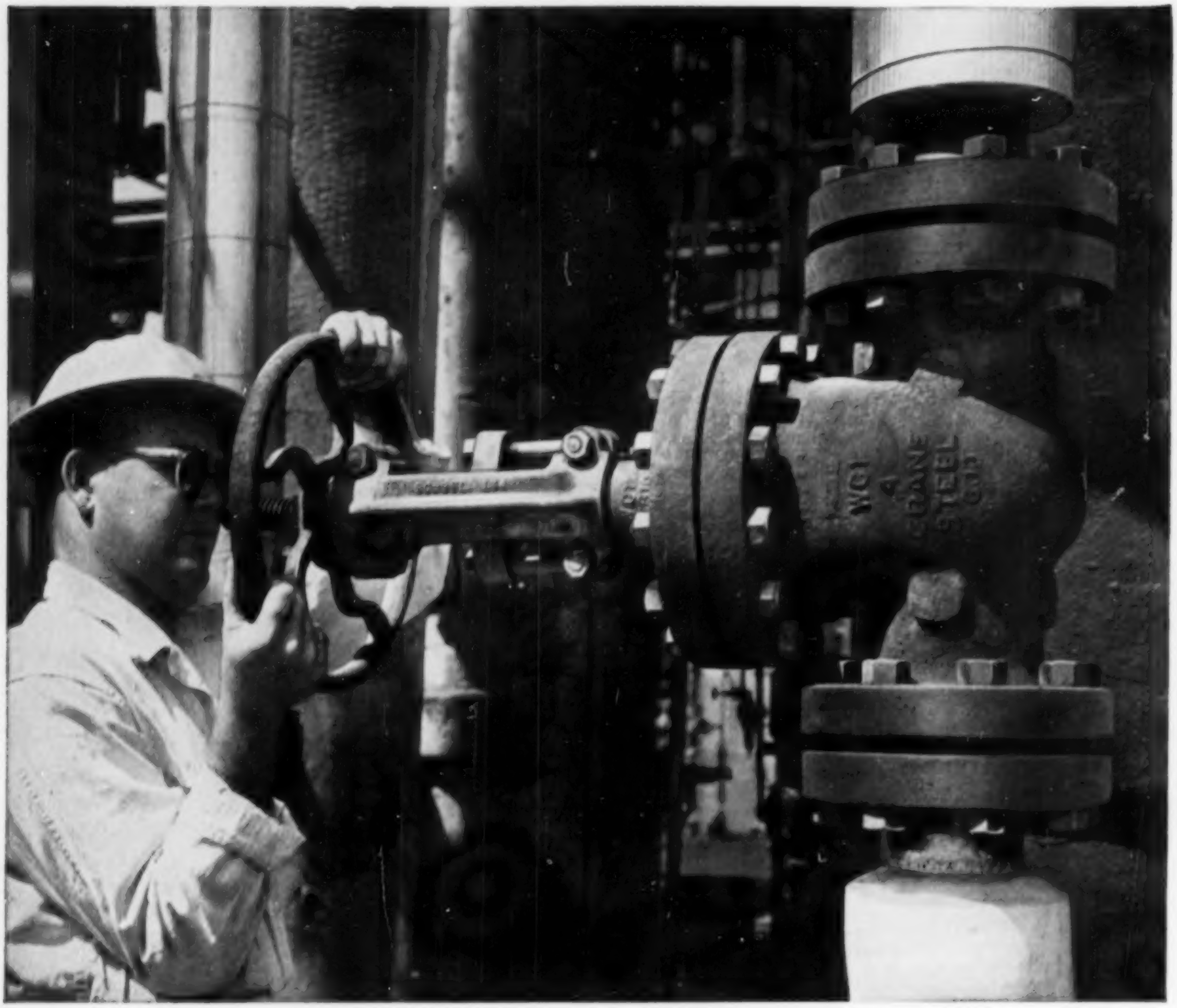


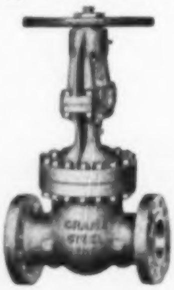
Two years on high-pressure hydrogen . . . no leakage . . . no maintenance!

Two years ago, Celanese Corp. installed this Crane valve in their large petrochemical plant in Bishop, Texas. It's a 4-inch No. 76XR 600-pound steel gate valve, on a line to a hydrogenation reactor. Pressure is 800 psi. and temperature 375° F.

What's the maintenance cost story on this valve—after 2 years of such severe service? *It hasn't cost a dime.* Celanese maintenance crews haven't been near it once with a wrench. Leakage? *Zero*—there hasn't been a trace of leakage during the 2 years the valve has been on the line.

Outstanding? Not for Crane valves. You'll find Crane valve performance records like this in chemical plants everywhere, and throughout industry. Crane's strictly quality design, materials, assembly and testing assure you of such dependable and low cost flow control service.

You'll find everything you need in valves and fittings in the complete Crane line. Get full information from your local Crane Representative, or write to the address below.



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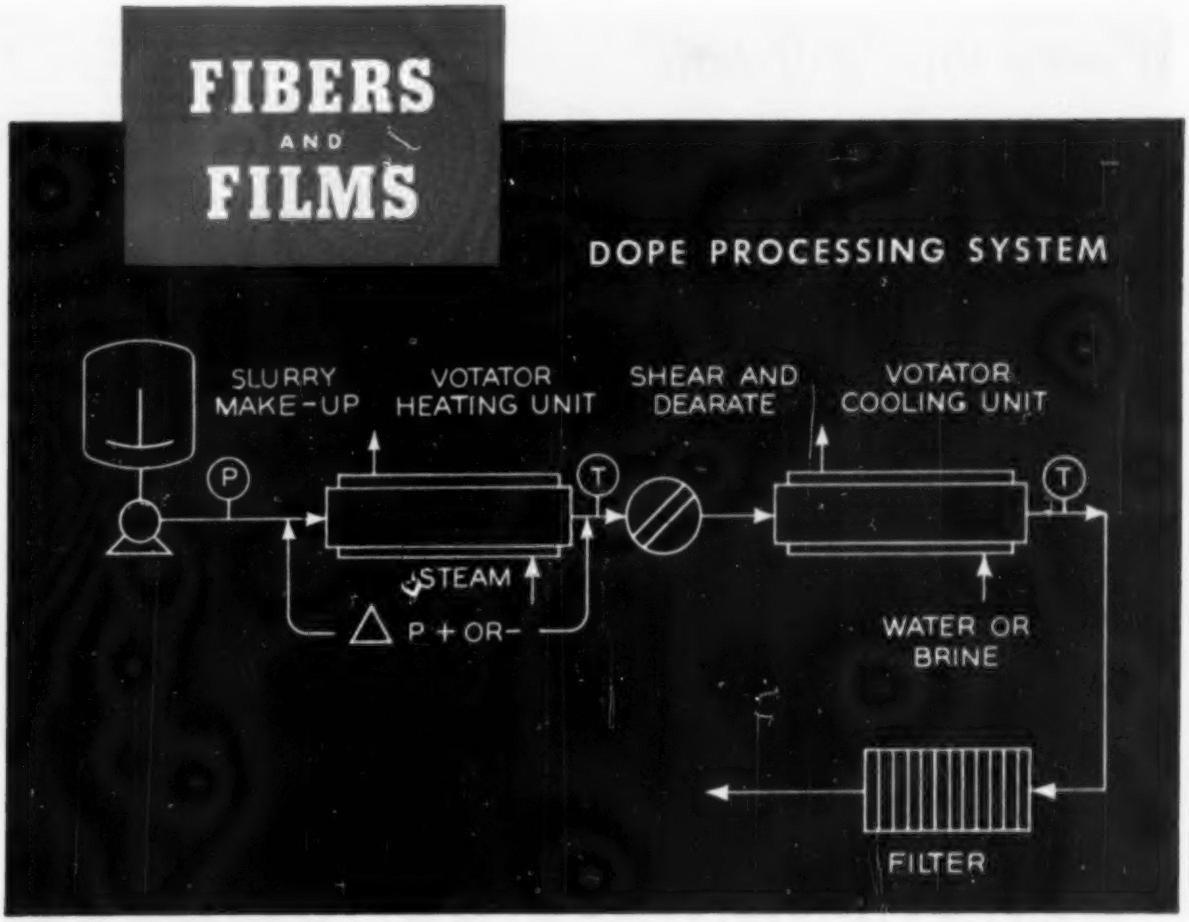

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Heat-sensitive fiber and film materials of high viscosity are being processed better, at lower cost with VOTATOR Apparatus. A new mutator shaft design of this scraped-surface heat exchange equipment makes possible these advantages.

- **Processes a higher viscosity range than conventional methods.**
- **Eliminates overheating of heat sensitive materials.**
- **Eliminates exchanger "plug-up" resulting in less down time.**
- **Low pressure drops or pressure gains reduce pump maintenance.**
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- **Continuous automatic operation reduces labor costs and holds maintenance to a minimum.**
- **Greater efficiency reduces utility cost.**
- **On many applications ceramic and other inert materials have been used in mechanical seals with good results and are always available.**
- **Long service life and minimum maintenance due to the new unique shaft design which practically eliminates wear.**
- **Equipment may be obtained in corrosion resistant materials of construction.**

Applications include polyacrylonitrile and acrylic copolymers, viscose (rayon and cellophane), cellulose acetate, cellulose ethers and polyesters.

The experienced engineers and laboratory facilities of Girdler are at your disposal to help apply this improved processing equipment to *your* problems. Write for copy of Bulletin V248.

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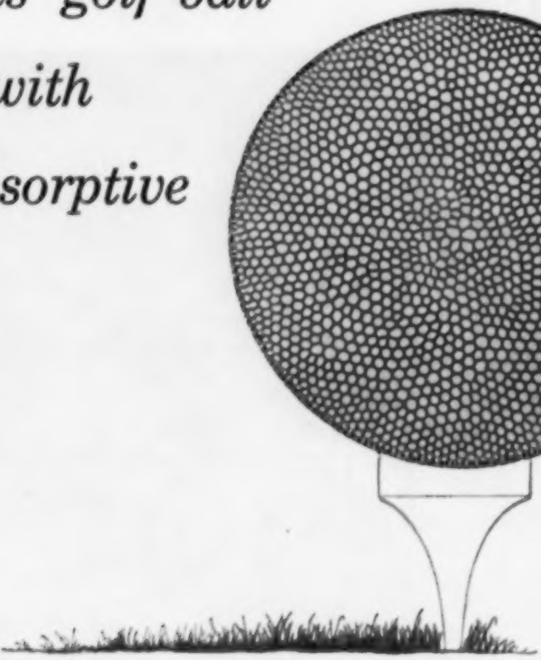
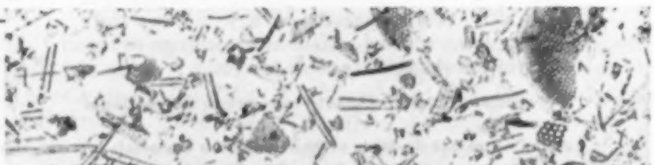
What's this "golf ball" got to do with greater absorptive capacity?



This magnification shows just one of the hundreds of different shaped particles found in Celite diatomaceous earth. Its genus is *Coscinodiscus* which means "disc-shaped sieve." Its species designation is *Radiatus* which refers to its radial structure. *Coscinodiscus Radiatus* is one of the more common marine diatoms and resembles a "golf ball" only when greatly magnified.

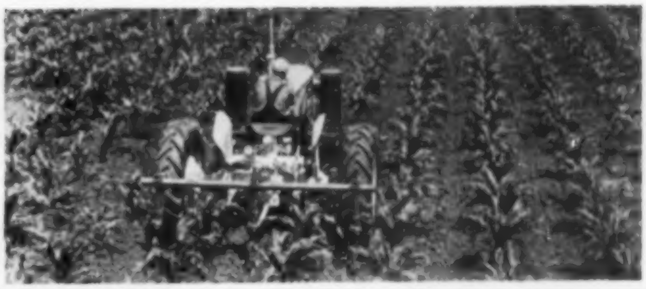
It's a particle of CELITE that absorbs more than

The secret of diatomite's remarkable properties is shown in this photomicrograph. The infinite variety of particle shapes and sizes gives Celite diatomite its exceptional performance characteristics in a wide range of process applications. The large percentage of voids both between and within particles like the "golf ball" provide porosity for high absorption.



Johns-Manville CELITE

Helps polishes soak up oil and dirt. In polishes for silver, other metals, glass and airplanes as well as automobiles, Celite absorbs residual oil, dirt and other solid matter. In addition, Celite imparts a delicate non-scratching polishing action.



Provides free-flowing fertilizers for uniform coverage. In ammonium nitrate fertilizers, highly absorbent Celite particles form a protective coating which helps prevent contact between crystal faces . . . thereby minimizing caking and assuring good flowability.

Controls viscosity in adhesives for corrugated paper. For precise control of viscosity and surface penetration, manufacturers of many types of adhesives rely on Celite's excellent absorptive capacity.

-the diatomite mineral filler twice its weight of liquid

Mix 100 cc of water with 100 grams of Celite* . . . the water is so completely absorbed that the mixture exhibits all the properties of a dry powder. This demonstration is visible proof of the high absorptive capacity of Celite diatomite fillers. Actually it will absorb 2 to 3 times its own weight before reaching its liquid holding limit. The reason is that approximately 93% of a given volume of Celite is composed of air spaces or voids. Despite its highly porous nature, however, Celite does not absorb moisture from the air.

In addition, Celite has many other unique properties which give it wide application as a mineral filler. Its high bulk—a cubic foot weighs only ten pounds—reduces outage in packaged powder products and provides the needed bulking action in many other formulations. The irregular shape of the particles and their hard silica structure adds reinforcing strength to paints and plastics. Other uses include concrete, insecticide diluent, paper and as a source of silica in "water glass" and "lime-silica" insulating materials.

Produced from the world's purest commercially available diatomite deposit, Celite comes in a wide range of grades. Each grade is carefully controlled for complete uniformity.

Ask your nearest J-M Celite engineer to tell you how Celite can help solve your formulation problems. He's backed by Johns-Manville's extensive research facilities and years of practical diatomite experience. Call him today or write Johns-Manville, Box 60, New York 16, New York. In Canada, write Port Credit, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

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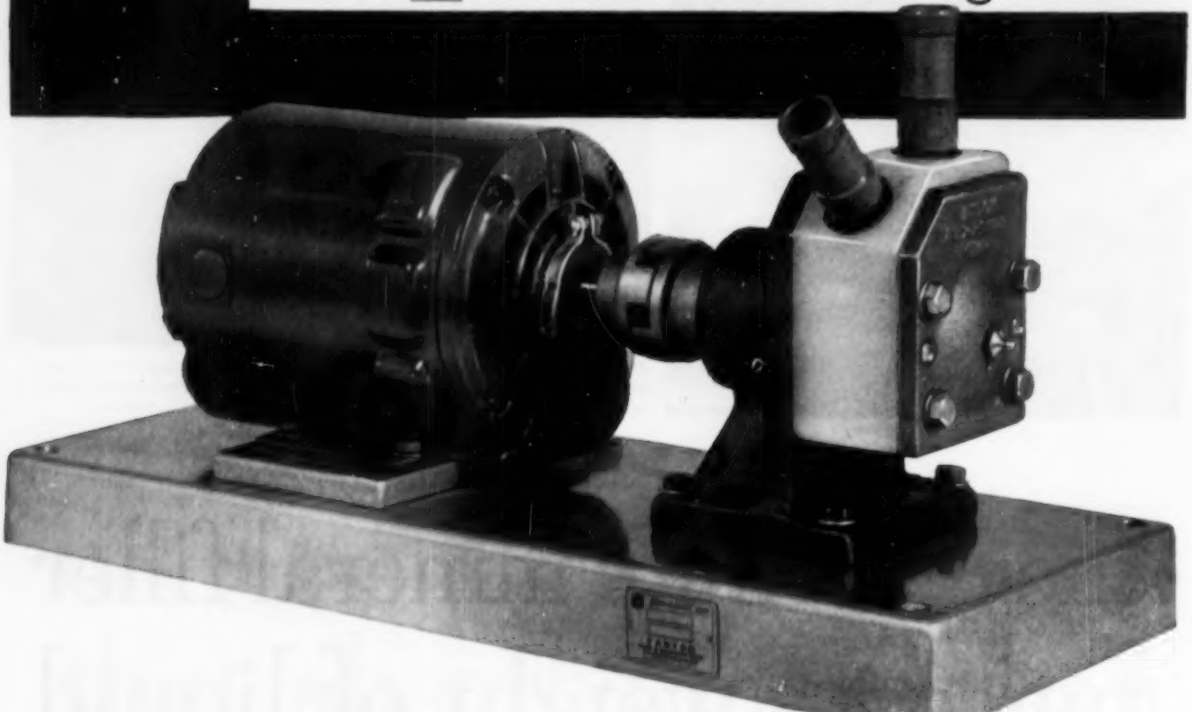
with no shaft seals or stuffing boxes



The unique Vanton "flex-i-liner" design *eliminates stuffing boxes, shaft seals, gaskets and check valves.* Fluid contact is limited to the inner surface of a plastic housing and outer surface of a durable precision molded plastic or synthetic flexible liner. This allows safe and continuous handling of tough corrosives and abrasive slurries.

"Flex-i-liner" pumps are furnished in these materials:

Polyethylene—"P" Series—Excellent resistance to strong acids and alkalies. Excellent general chemical resistance and non-contaminating. Recommended for such typical applications as: Hydrochloric, Chromic, Hydrofluoric, Nitric, Phosphoric and Sulphuric acid: Calcium and Sodium Hydroxide; Sodium Hypochlorite; Hydrogen Peroxide and Distilled Water.

Buna N—"N" Series—High temperature resistance and suitable for use with weak acids, strong alkalies, vegetable and mineral oils. Recommended for such typical applications as: Plating Solutions, Chemical Salt Solutions at elevated temperatures; Petroleum Products; Tuna Fish Oil; Shortening; Ferric Chloride and Tile Glaze Slurry.

Bakelite—"B" Series—Excellent for organic solvents and organic acids. Good for weak acids and alkalies. Recommended for such typical applications as Acetic, Formic and Oleic acids; Ethyl and Methyl Alcohol; Carbon Tetrachloride; Gasoline, Kerosene, Fuel Oils; Photographic Solutions and Glycerine.

Liners are available from stock in Neoprene, Buna N, Gum or Natural Rubber, Hycar, Hypalon, Silicone, Vinyl or Compar.

Self priming with a gentle pumping action, Vanton plastic "flex-i-liner" pumps are available in capacities from ⅓ — 20 GPM and can be furnished direct connected to constant speed or variable speed motor equipment. Vacuums up to 26" Hg. are developed.

Bulletin VP562 on request.

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VANTON

PUMP & EQUIPMENT CORP.

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About our authors

Henry E. Wessel ("Economic Evaluation") has just joined Monsanto, where he is manager of marketing research in the General Development Department. He was once before with Monsanto, from which he went on to become manager of engineering economics for Midwest Research Institute. Until recently, he was manager of Product Development for International Minerals & Chemical.


Wessel

F. C. Jelen ("Capitalized Cost") tells us that he is often asked what is the economical time to trade automobiles, but that the formulation of a scientific answer is made difficult by the owner's never being able to state how much pride of ownership of the 100 extra horsepower is worth to him. This makes the answer "indeterminate." In other words, Jelen concludes that the pattern for decision should be: trade as soon as the credit firm will finance the transaction. Mr. Jelen is with Allied's Solvay Div.


Jelen

Two authors ("Interest Rate of Return") have been promoted this year: **Robert J. Reilly** was made director, and **James B. Weaver** assistant director of Atlas Powder's Economic Evaluations Department. Both started out as chemical engineers in R and D.


Reilly

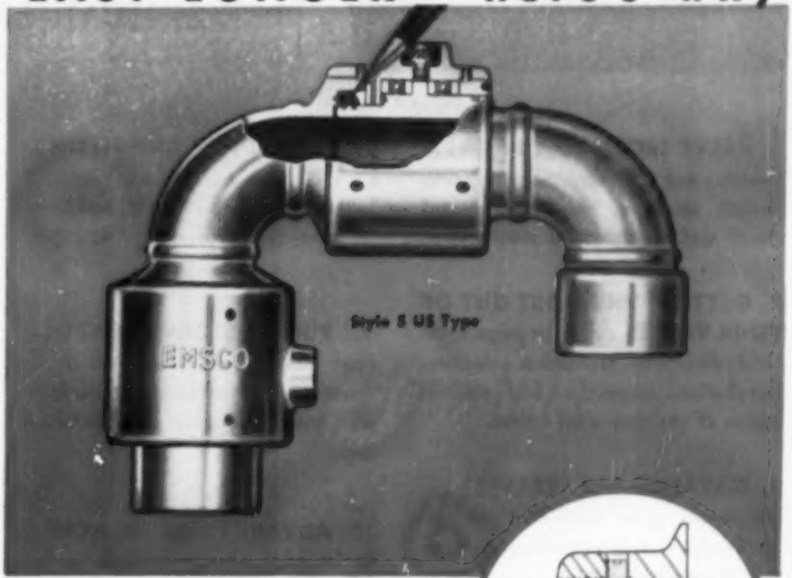

Weaver

Hamilton R. Wager ("The Appropriation Request") is a chemical engineer engaged in technico-economic studies and recommendations with Arabian American Oil Company, otherwise known as Aramco. His work takes him quite often to Europe and the Middle East, which he says affords some contrast with New York's Manhattan, where he lives. Besides the above, he engages in market research and development, and engineering planning activities. Before joining Aramco's staff, he spent several years as an executive assistant with Allied Chemical and Dye.


Wager

(Continued on page 47)

EMSCO SWIVEL JOINTS LAST LONGER — here's why



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5. VALVES TO COMBAT CORROSION . . . 75 questions and answers selected from Cooper Alloy valve clinics covering materials, operations, service problems, installation and repair.

6. STAINLESS STEEL VALVES AND FITTINGS IN THE PAPER INDUSTRY . . . Eight page technical article covering alloys, valve selection, design factors, installation, maintenance, operation and inspection of stainless steel valves and fittings used by the paper industry.

7. PLASTIC PUMPS . . . Four page folder describing the Vanton "Flex-i-Liner" pump. Full and cut-a-way views, plus performance charts and material selection hints are included.

8. PLASTIC PIPE AND FITTINGS . . . 8 page catalog on Vanton P-Line (PVC), N-Line (Buna N) and S-Line (Styrene) pipe, valves and fittings.

9. PUMPING CORROSIVES . . . Four page article describing the transfer of hydrochloric, formic, lactic acid and salt solutions at Litho Chemical.

10. ADVANCED KNOW-HOW . . . Series of case studies showing how advanced know-how made possible the economical production of high alloy products considered difficult or impossible to cast.

11. MATERIALS SELECTION CHART . . . Four page chart designed to assist in the selection of the most economical alloy for a given corrosive problem. More than 350 specific corrosives are included.

12. DESIGN CONFERENCE . . . Special edition of Newcast containing the technical papers presented at the Cooper Alloy Design Conferences. Subjects incude Casting Design, Shell Molding, Cast Weld and New Materials.

13. ALLOY REFERENCE CHART . . . Revised four page pamphlet listing alloy designations, applications, properties and analysis of corrosion and heat resisting alloys.

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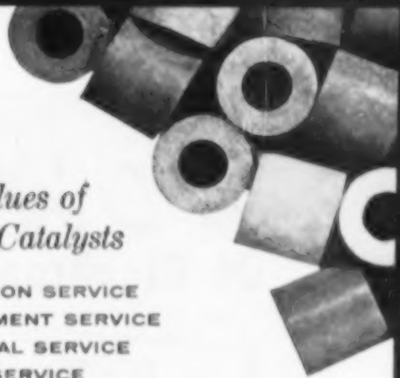

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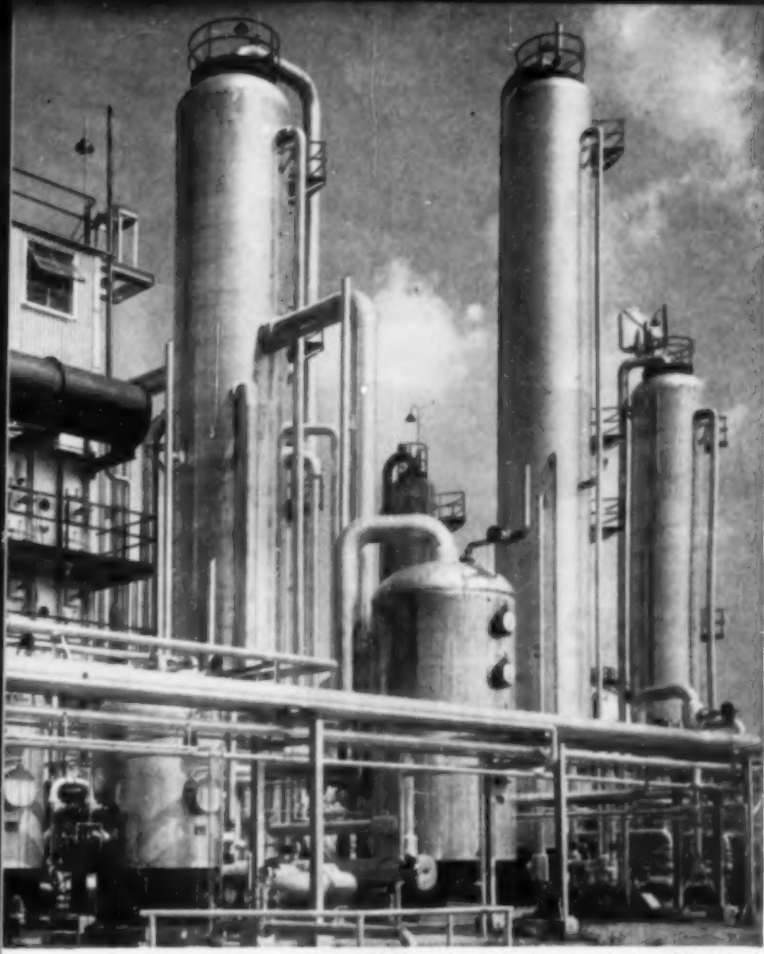
How this full-scope catalyst service boosts your flow rates



INCREASES AMMONIA PRODUCTION 30 TO 40% when required at Mississippi Chemical Company with negligible increase in fuel per unit of ammonia produced. Girdler Catalyst Specialists worked closely with this customer and demonstrated benefits of a switch to its newly developed G-29 for use in generating synthesis gas. This is a good example of the valuable work our full-scope catalyst service performs to boost production and lower costs for many processors in a wide range of applications. Find out how this service can work for you to your advantage. Write on your company letterhead for booklet describing facilities of Girdler's Catalyst Department.

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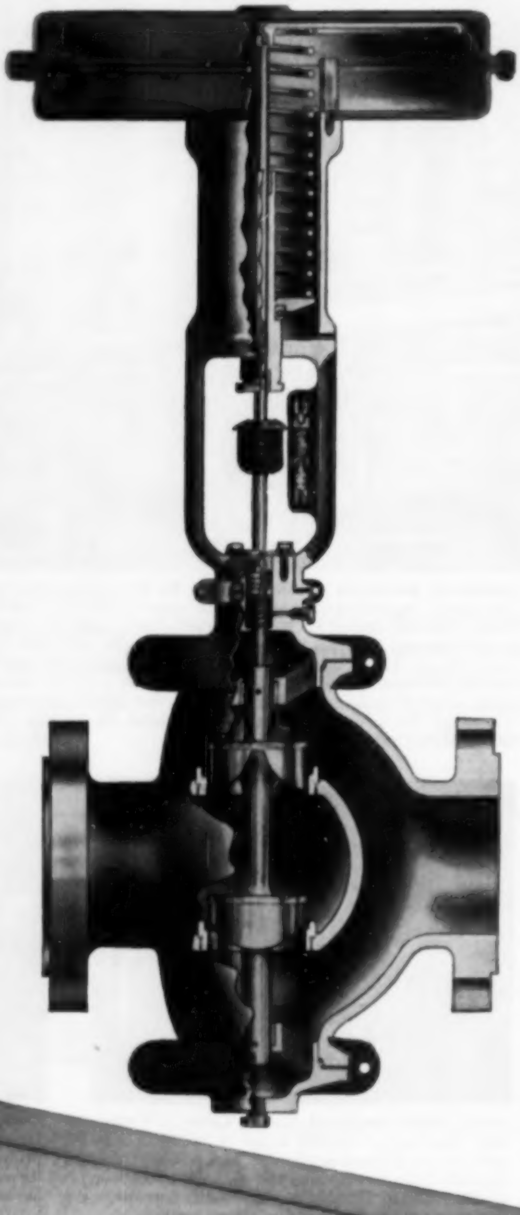

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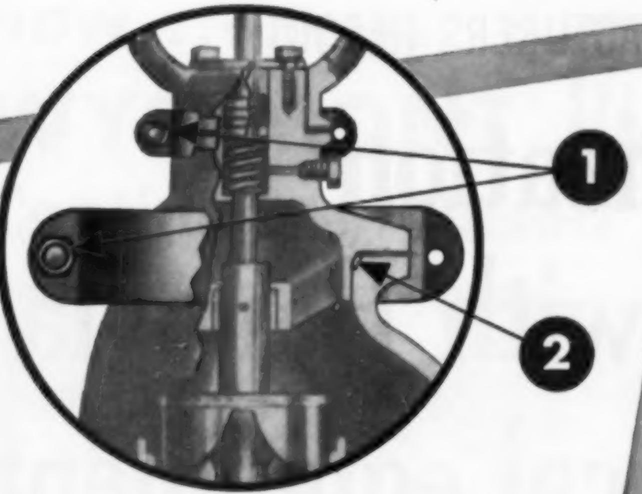

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...Automatically adjusts with changes in temperature!

...Eliminates the annoyance of gasket replacements!

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About our authors

(Continued from page 43)

R. M. Wheaton ("New Uses for Ion Exchange Resins") who is division leader in Dow's Physical Research Laboratory, tells us: "I feel that my major contributions to the field of ion exchange have been quite diverse. As discussed in my paper, I have been interested in finding new applications for ion exchange materials, other than conventional ion exchange reactions. My feeling is that the name ion exchange resin itself tends to suggest a false limit to the scope of these materials. This is pointed out by such non ion exchange reactions as catalysts and ion exclusion."

R. E. Tomlinson and **E. A. Coppinger** ("Heat Problems in Disposal of Radioactive Wastes") are with GE in Hanford. Coppinger, as a chemical engineer, has developed pertinent unit operations and evaluated economic and process feasibility of development data application. Tomlinson got his start in the nuclear field with DuPont in 1944, assisting in the construction and start-up of the first chemical separations plants producing plutonium on an industrial basis at Hanford. Later for GE at Hanford, he worked on the construction and operation of three major solvent extraction facilities for the isolation and decontamination of uranium and plutonium. In 1955 he presented a paper at the Geneva Conference on "Practical Limitations of Solvent Extraction Processes."

Tomlinson

About our Cover:—CEP's covers attempt to symbolize some particular aspect of the "CEP Special Feature" section which appears in each issue. This month, the theme the editors thought most exciting to symbolize was "appropriations request." Admittedly just another kind of a touch for money, the kind advocated for widespread adoption by the chemical engineer does not lend itself to artistic interpretation as easily as would a tearstained letter from the young hopeful at college. An appropriations request, we were told, looks like a book. Actually, it's a bound report. What distinguishes it from any other bound report? Its organization and comprehensiveness, showing that its authors anticipated and answered just about every question that might come to the mind of a dollar-minded executive. We trust that our cover "tabs" will remain indelibly in your imagination, reminding you to be comprehensive without being tedious.

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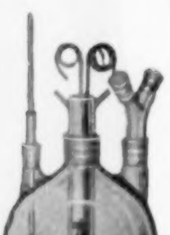

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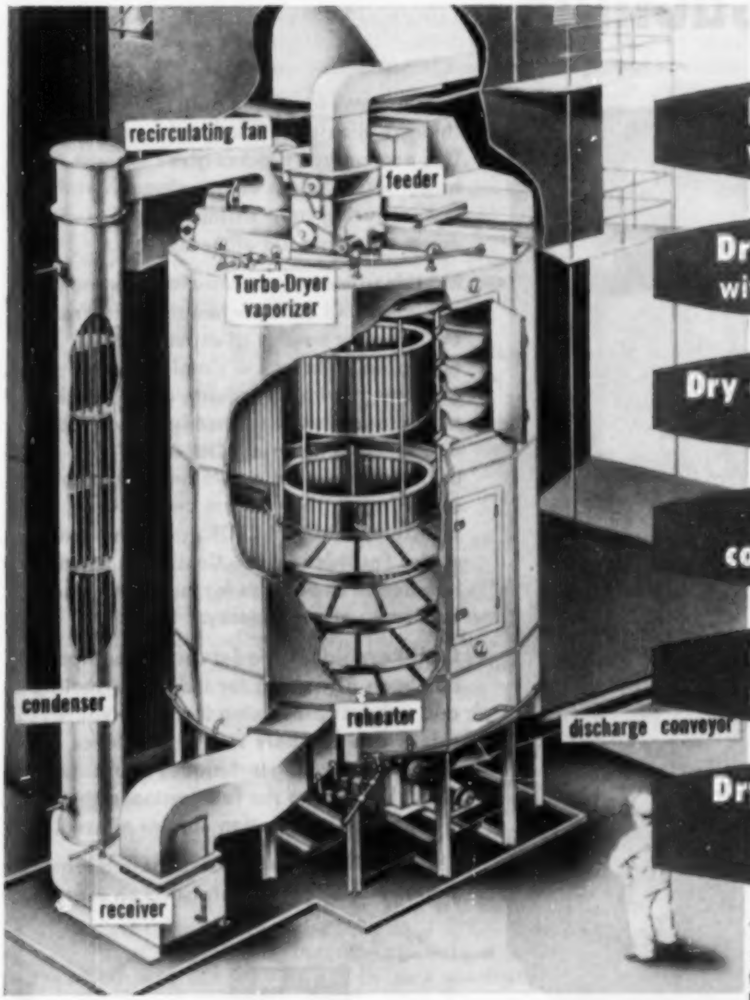

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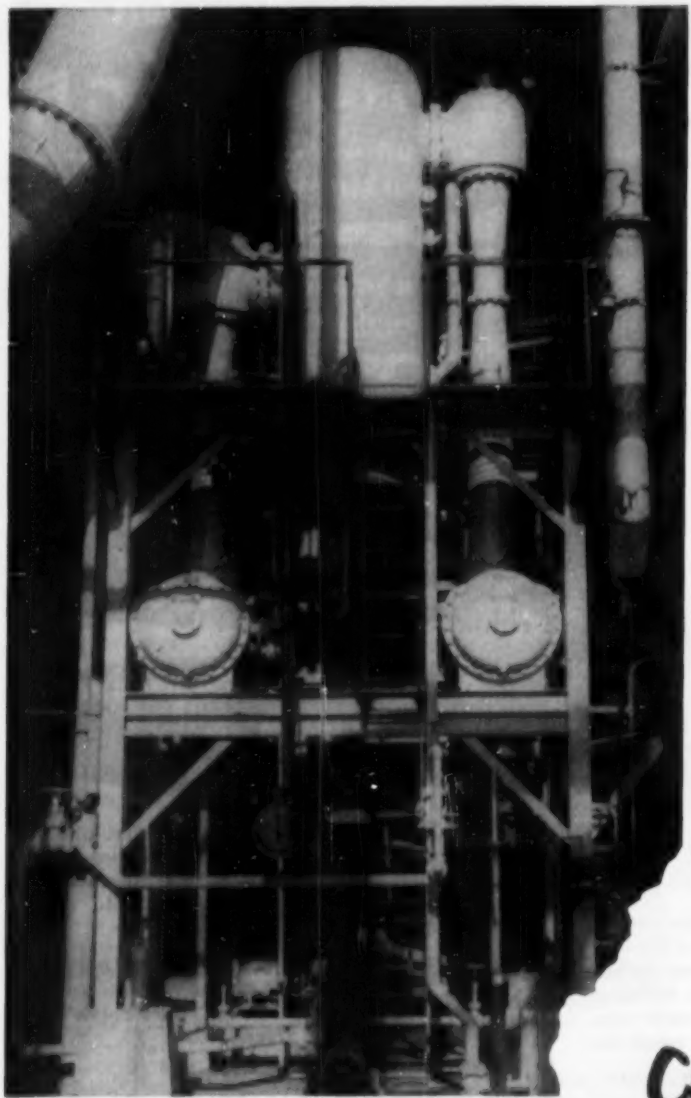

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CEP trends / SUEZ MELEE

While diplomats huddle in conference and concoct plans and methods for working out the crisis brought about by Egypt's nationalization of the Suez Canal, the oil industry and the chemical industry both here and abroad are profoundly disturbed over the long-range implications of the Middle East situation.

The effects upon the economy of both the United States and of Europe of a disruption in shipments of oil from the Arab world will be far reaching and at this time unpredictable. Both British and American oil companies have huge stakes in Arabian oil. A recent Wall Street banking survey showed that British Petroleum last year had 280 million bbls. of its production shipped by tanker and not carried by pipe line. Gulf Oil Co. had the next largest stake with 200 million bbls. in this category. Royal Dutch had 150 million barrels. Socony Mobil, Standard Oil of California, Standard Oil of N. J. and the Texas Company range from 50 million to 90 million barrels of Middle East tanker-carried oil, enough to affect these firms considerably if drastic events occur.

Of course plans are on foot not only for replacing our own consumption of Middle East crude, but also for supplying Europe with oil from this hemisphere if a workable settlement cannot be made with Egypt. A Middle East Emergency Committee, made up of representatives of U. S. oil companies operating abroad, has been set up to handle such an eventuality as did a similar committee during the Iranian crisis.

Powder Keg

But what is more disturbing and cannot be resolved probably for a long time is the whole sizzling powder keg of the Arab states which supply a major portion of the oil for Great Britain and the rest of Europe.

The difficulty is that social changes in the Arab world are bringing in new governments which are potentially weak, unstable, and unreliable.

So there is the immediate problem of getting oil in tankers through the canal, or of shipping it around Cape Horn if this should not prove feasible, and the long range problem of what will happen if other states in the Arab world begin to press the huge oil firms that have developed Middle East oil. The economy of that part of the world is based on oil, and the world petroleum economy is completely involved with that same oil. On the side lines is Soviet Russia, toward which the Middle East and Asiatic countries have at least a neutrality and at worst a sympathy.

Of course there is the large question of how much Russia could actually help if the Arabs swing toward them instead of toward the west, but in time of turmoil, when unstable rulers try to promote themselves, practical considerations might give way before political maneuvering.

European Requirements

If the Canal should actually be closed down to oil shipments, either because of the physical inability of Egypt to manage it or because of a boycott by the Western oil shippers who own concessions in Arabia and neighboring countries, around 2 million bbls./day, or 500 million bbls./year, of Canal oil shipped to Europe would be affected. Oil going around Africa takes about three times as long, not to speak of higher freight and insurance costs. Only about 120 million bbls. (½ million/day), nearly 40% of production, moves from Saudi Arabia to the Mediterranean via the Trans-Arabian pipe line. By shifting the Canal-using tankers to the longer trans-Atlantic run, it is estimated that the U. S. could send to Europe about 1 million bbls./day, plus about another 200,000 bbls./day from Venezuela. This, added to the ½ million bbls. from the Trans-Arabian pipeline, would still leave a serious shortage and might mean rationing in Britain and Europe, where consumption needs are roughly estimated at 3 million bbls./day. It could mean a serious disruption of the burgeoning European petrochemical industry (see Trends, May, 1956), which has been depending to a great extent on the new supplies of oil from Arabia. It could also mean serious exchange difficulties.

Fixed Prices?

If the North and South American crude surplus should go to Europe, an obvious result would be a tightening in price levels here and an endeavor to raise the price to Europeans. This brings up the question as to whether the U. S. government would be obliged to step in and fix export prices. There would also probably be a need for some sort of government credit arrangement to facilitate buying by Europeans who are still short on dollar credits.

From the long range standpoint, only increased tanker capacity will make the large oil consuming countries secure from supply crises when a given producing area or transportation artery is cut off. That something is being done about this is indicated by the 15 million deadweight tons of new capacity now under way in the world's shipyards, to be added to the 40 million dwt. presently afloat. Of this 15 million, approximately 2.7 million dwt. will be in 77 supertankers ranging from 32,000 to 83,900 dwt. individual capacity.

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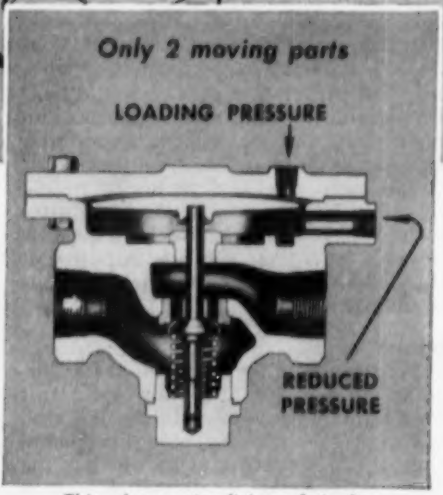

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CEP

opinion and comment

This Amazing Age

TRYING to read the technologic significance (or consequence) behind the lines of newspaper stories on international affairs can be exciting, particularly when the great shipping lanes of the oceans, the means for generating power, and the patterns of raw material availabilities are all more or less in a constant state of change.

Certainly there has never been a time when, not at war, we have been able to experience a state so filled with tremendous potential for technologic change. And yet, to many technologists what is going on in the way of great shifts in the world today may seem quite remote and apart from their daily situations. Many who experienced the quickening pace of industrial technologic activity in the late 1930's must feel that our great industrial machine is today geared to international affairs in a peaceful way which is comparable to the way it was when we were preparing to defend ourselves in a world already at war.

What has happened is well known, if not consistently appreciated, by everyone. Our industry, backed by our capacity for technologic development, has become a potent force in making possible our nation's adjustment to a world in which major changes are taking place. What a trump card it must be for our diplomats to know that, for example, cut off suddenly from all natural rubber we could gear ourselves into a "crash" program of devising and erecting plants which would multiply the presently proved isoprene polymer into large-scale being!

In the Suez crisis, as with the Iranian oil crisis, solution on the basis of the technologic approach may serve to resolve matters peacefully.

We are today in a state of affairs which provides, in many cases at least, the incentive for vast technologic change brought on by industrially headed groups, capable of accomplishing results during peacetime of a magnitude which formerly went along only with wartime emergency.

Of course, there are not enough qualified individuals, enough facilities, or enough tax dollars yet to permit the making of major efforts in all desired directions at once. Perhaps we shall never be able to afford such luxury.

It is exciting, however, to think of what may very well be ahead for those trained and experienced in the conversion of materials to higher forms. Chemical engineers should be happily aware of the important effects their developments and large-scale extrapolations are having in the field of international relations.

J.B.M.

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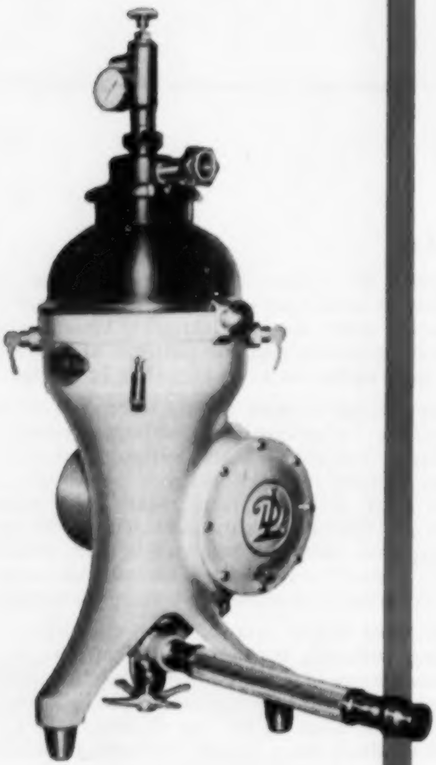

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Left to right around the table: Wessel, Weaver, Reilly, Wager, Jelen, Tielrooy, and Krase.

ECONOMIC EVALUATION

Group of top-ranking analysts terms it one of most important aids to non-technical management—one which can be readily acquired by the chemical engineer. This condensed version of the round table discussion at the Los Angeles A.I.Ch.E. National Meeting points up practical conclusions.

Wessel: As you authors of the economic evaluation papers know, the purpose of this recording session is to enable us to discuss some of our own views and our companies' interest in economic analysis as a tool for the chemical engineer. I think it is an important tool—as a matter of fact, as chairman of a committee on this subject at my company, I am right in the middle of a program to develop better economic evaluation procedures. As the information in the symposium papers is based on actual operating experience, I regard it as of real practical value.

Weaver: We in economic analysis play the important role of making management's job easier as our companies grow. With secrecy not being too important a factor in the techniques of capital expenditure, it is possible for us to share our evaluation techniques as we are doing in this symposium.

Reilly: The field of economic evaluation has been under-emphasized in the past to chemical engineers. Yet the job of translating scientific and technical information—through economic evaluation—into business data which can be used by nontechnical business management is a vital function, which can often be done best by chemical engineers.

Krase: I am strongly in favor of chemical engineers endeavoring to raise the general level of their economic competence.

Teilrooy: The more that can be done to bring economic evaluations closer to the realities of corporate balance sheets, the more we will be keeping the expansion of the chemical industry on a sound economic basis during periods of rapid growth, such as the present. During such periods, people are liable to go into projects on an improper economic basis, making the competitive situation bad all around.

Wessel: I am sure we all feel strongly about the importance of our subject. Now I'd like to call first on Mr. Wager to comment on how comprehensive he feels economic evaluations should be.

Wager: Husbanding a company's capital assets makes it necessary to make properly controlled appropriations of funds for even the smallest, most prosaic capital items and also to use the same care with retirements and transfers of capital facilities, etc. Care of this nature can pay off in such ways as providing sound records for bookkeeping and accounting, the facilitating of future engineering estimation work, and the checking up on results being obtained by the general flow of construction fixed capital. As I have endeavored to bring out in my paper, a well thought out appropriations request, based on an adequate economic evaluation and complete as to information needed by management in making its decision, is a very important contribution which only the man familiar with the processing can make. (See pp. 402-404).

Wessel: For various reasons, it may sometimes be desirable or even necessary to make changes in a project after it has been authorized and in the construction or purchase stage. How are such changes accommodated by the appropriations request?

Wager: When such changes occur, they can usually be handled through a supplemental or, if additional funds are needed, a deficiency appropriation. The same general form of request as for the original project would probably be submitted to management. The supplemental request would explain the necessity for the changes and for the additional funds, if a greater expenditure than the original cost is projected. It would also cover the effect, if any, on the benefits originally estimated for the project.

Reilly: The size of an appropriation which requires an economic analysis and justification depends a good deal on company size. A $100,000 expenditure would be much more run-of-the-mill in Du Pont, for instance, than in our company (Atlas Powder). In the companies with which I have worked, some sort of formal justification is usually required for projects as small as $10,000. The same general form of justification is used up to levels of several million dollars.

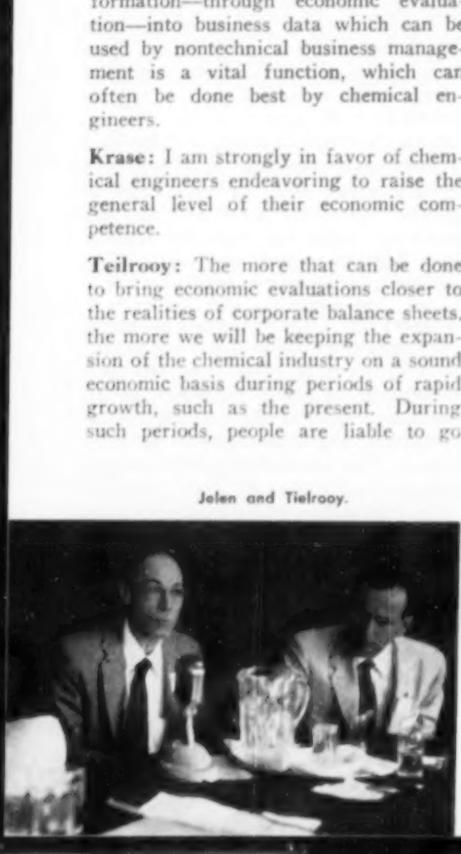
Krase: Most of the low-return investments which come up seem to be small ones, that is, under a million dollars or so. In Du Pont we have a system by which various levels of management have limits of authorization in the handling of appropriation requests. For example, a department head can authorize expenditures up to a certain point. A vice-president can go somewhat further. If it exceeds the vice-president's powers, it must be approved by the Executive Committee. Really large projects must also be approved by the Finance Committee. So, with this gradation down the managerial ladder, a lot of projects don't ever reach top management.

Reilly: The allocation of responsibility for specific levels of expenditure is quite common.

Wessel: Mr. Tielrooy, with regard to pre-profit expense, is half of the money in this category ordinarily added to capital cost?

Tielrooy: Certain items of cost prior to start-up can be included as part of the fixed capital or they can be treated as expense and deducted from the initial earnings. The limits here are determined on the one hand by what the Internal Revenue Department will permit and on the other hand by the policy of your company. In general, such items as staff salaries and training, start-up

Jelen and Tielrooy.



- **Interest-rate-of-return offers powerful evaluation method.**
- **The appropriation request can take account of the time value of money.**
- **Chemical engineers can play a vital role in management decision-making.**

AT THE ROUND TABLE ►

Chairman: H. E. Wessel
Monsanto

F. C. Jelen
Solvay

N. W. Krase
Du Pont

R. J. Reilly
Atlas Powder

J. Tielrooy
Brea Chemicals

H. R. Wager
Aramco

J. B. Weaver
Atlas Powder

expenses, and losses during initial operation are usually considered part of the cost of operating the plant and, as such, are expenses and can be deducted from earnings. So, if you have any profit against which to charge these expenses, you can save an amount equal to 50% of such expense.

Wessel: I'd like to turn the discussion around at this time to cash flow analysis. Exactly how widely is such a method employed and is it applied only to certain classes of projects?

Reilly: We have been able to identify two companies using the "interest rate of return" (or "discounted cash flow") method for economic evaluation,* neither exclusively. In both cases, it is calculated in addition to payout time and return on average book investment. This may be because people must become acquainted with the new method while having something based on experience with which to compare it. We would be glad to learn more of actual cases of use of this method in industry. It can certainly be applied across the board for evaluation of any income-producing project that requires an investment.

Tielrooy: Mr. Reilly, in using your method do you actually take into account that, during the estimated life of the project (which may be 10 or 15 years), working capital requirements vary from the start until the end of the project, and that the capital involved at any one time varies continuously as you charge depreciation off during the life of the project?

Reilly: We do take working capital variation into account if we are able to get a forecast sensitive enough to predict such changes. A forecast of rapidly rising sales, for instance, would allow inclusion of a changing working capital. Incidentally, in making a working capital estimate, we deduct "accounts payable." Payables really represent a temporary investment by a supplier in your business—they are in turn his receivables.

The second part of your question refers to the recovery by the company of its original investment through depreciation set-asides. Our method does look upon the recovery of the accruals as a cash income. Ours is strictly a cash method and takes into account *all* cash receipts. Depreciation allowance is put in as a cost before tax, and is added back to profit after tax, as a cash receipt of the company. Some of the other rate-of-return methods do not easily take into account variation in fixed or working capital during the life of the plant. If the average investment over the plant life is used as a basis, changes can be considered, but I would not know how to handle calculation of a return on original investment if the fixed or working capital increased after the start of the project operation.

Tielrooy: At Brea, we actually try to anticipate initial capital expenditure plus any contemplated future expansions for the life of a project, which is typically fifteen years. However, increases in capital investment and working capital as well as changes in profit are estimated on a year-to-year basis. From this procedure, one can, of course, arrive at your method by correcting back to a common base. We don't normally do this. For a great many projects the curve is so typical that we use one criterion—we take the average investment over the fifteen-year-period and the average profit over the same period. A certain per cent return is considered adequate for a certain type of project. This method is applicable only if you are dealing with an established type of product.

Krase: At Du Pont we do not use the cash flow method for appropriation requests. We stick to the good old-fashioned return on investment using original book values. I don't agree that this is the best method. Far from it. Obviously, investments made back in the twenties and those made in the fifties are based on different dollars. On the books, they appear only as dollars; this results in a distorted view which appears to make the older investments look more advantageous.

As far as year by year forecasts over a period of fifteen years are concerned, we don't do anything like that. With the high rate of obsolescence that characterizes the chemical industry today, I'm rather surprised that you can look so far ahead to consider variations in investment, to say nothing of working capital and the other factors. When you get into an area where technical business judgments are predominent, there are so many uncertainties as to the behavior of a product that you come down finally to a question of judgment which doesn't require all this detailed analysis.

Tielrooy: I certainly agree with Mr. Krase, particularly with reference to many of the new products which his company has pioneered. It must have been difficult to determine whether nylon, for example, would be off the market in a year or whether in fifteen years it would be a big success. With a new product having desirable properties, you can assume a high profit potential, and realize it for an initial period if the product goes over. If it doesn't go, you'll lose your shirt. In such cases, the fifteen-year analysis is neither desirable nor necessary.

I was speaking earlier of products which have been in existence for some time or which are relatively similar to other products whose future can be predicted with some certainty. For instance, fertilizer ammonia will be used twenty years from now as it was used twenty years ago. On this type of product we would use the fifteen-year analysis. Again we make the assumption that the general economy will be constant during that period.

Wager: Mr. Krase's observations on the importance of judgment are interesting. A great, and probably important preoccupation of many engineers is the seeking after and the making of refinements and improvements in techniques. Cost estimating is still far from being an exact science. Thus, judgment enters the picture at the engineer's level. It is the factor which should tell the engineer when he has carried his calculation and predictions as far as is warranted by the particular set of circumstances applicable to the problem on which he is working. The cultivation and development of judgment of this

* See article "Interest Rate of Return for Capital Expenditure Evaluation"—Weaver and Reilly—Page 405 this issue.

sort will facilitate an engineer's progress toward executive responsibility.

Krase: I would like to make one more comment about forecasting. During World War II, most companies were concerned with projections for the period to follow the end of the war. Great mistakes were made. Industry was caught short. They felt that there would be the usual post-war depression, particularly in the plastics field. Everybody was surprised when we had a period of sustained prosperity which we are still in. The general economic climate is a terrifically important factor which even the best management cannot forecast with accuracy.

Wessel: I would like to suggest that projections are inherent in the situation. Unless you have a fairly rapid pay-off period—two years or so—you're talking about money which you are not going to get back for six, eight or ten years. So, you are forced to make projections.

Reilly: No matter what assumption you use as a forecast, fixed capital is irretrievably committed for the life of the project. Therefore, before a decision, we believe it worthwhile to spend considerable time and effort to make the best possible forecast of markets and also of general economic conditions.

Jelen: The cash flow method actually does discount future guesses in the sense that an error of a dollar today is an error of a dollar, but an error of a dollar in the future is considerably less, especially if it is a question of five or ten years.

Another method is to take limits. Even if you can't predict the future exactly, you can take high and low limits and see how they affect the problem as a whole.

Reilly: The problem of treating limits is that of estimating two or more factors instead of one. I assume that by limits you mean estimates of minimum and average performance. In the case of performance ten years off, I do not know that the basis for estimating minimum would be any better than for estimating average.

Jelen: No, I didn't mean it that way. You can estimate your future and then calculate how much it would have to be off to swing the whole estimate one way or the other.

Wessel: I think we are all in agreement on the subject of rate of return on investment as a suitable means for evaluating a project, but not so much so on the specific application of this concept. How is risk read into this equation by any one of the methods of calculation of rate of return? For example, today's insecticides may be replaced by new ones tomorrow. Rapid obsolescence is common in antibiotics. How do you handle the risk factor to economic analyses for these products? This, of course, is a management function.

Wager: It seems quite possible that, even after all the engineering reports, market forecasts, etc., are in, management may, in considering any proposed project, want to reserve to itself the evaluation of and decision on risk. It might be nice to have equations or even calculating machines to take this load off management's shoulders, but I am not convinced of the value of such props. The equations, formulae, etc., used in various procedures for calculating return on proposed investment are at best only a guide, and they must be used with discretion and interpreted carefully.

Weaver: The final decision is certainly the prerogative and the problem of top management. However, there is considerable that a profitability estimator can do to assist management's thinking. One way of accounting for risks in estimates is to require higher rates of return for the projects that show more of a risk. Another way is to investigate the sensitivity of the calculated rate of return to risky factors such as market growth or obsolescence. Using our interest-rate-of-return method, a recalculation can be made assuming that the market takes five years longer to grow to capacity than indicated by your "best estimate." Similarly, the effect of a plant shutdown due to obsolescence can be calculated. Such figures can assist your management to a decision.

Krase: When you look at the components of total investment, you have working capital, allocated facilities, and direct investment. Presumably the risk is least on working capital, intermediate

on allocated facilities such as a power plant, and greatest on direct facilities which are specialized.

It has been proposed that, since working capital is at very little risk, we perhaps ought to be content with a mortgage rate of return, that is, the going interest rate. For general or allocated facilities, where the risk is somewhat greater, you should require a somewhat higher return on that portion of the investment. On direct facilities you should require the highest return because the risk is greatest. This system, however, has some real disadvantages. In the first place, it would tend to throw the whole investment program into a type of investment which is perhaps not the best type in the long run. It would favor investments which involve a high working capital, 50 or 60 per cent of the total investment. On such investments an acceptable rate of return can be shown without earning much money. What would be the result? You would soon be fabricating and selling a single product. In other words, you would be making no technological contribution.

Under modern competitive conditions there are a number of factors that make for success. A good research organization that can make improvements in product and process and create patent protection for the capital that is being risked is one factor. Another is to venture out into areas that may involve difficult technology or large resources or both. The return on investment standards of a company can provide incentive for pioneering which can constitute an important contribution to real progress.

Left to right around the table: Reilly, Wager, Jelen, Tielrooy, Krase, Wessel, and Weaver.

THE APPROPRIATION REQUEST

—an instrument for control of capital changes

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Through its Survey of Current Business, the United States Department of Commerce advises that the chemical industry, alone, in the fourth quarter of 1955 spent approximately 300 million dollars for new plant and equipment; a high rate of expenditure continues currently in the chemical, petroleum, and related fields. Year by year, money is thus transformed into the capital assets of the process industries, with the conviction that profits will grow as a result.

Top corporate officials, as part of their total responsibility to corporate ownership, must use diligence in conserving capital funds for the most desirable uses, and also in controlling other changes in existing capital assets, which comprise all the physical productive facilities of business.

The usual method of allocating funds destined for capital uses is through executive authorization of individual, or in the case of small or routine projects, blanket, amounts, to be expended for specified purposes. Since the appropriating of sums for such expenditures is a discretionary matter with the authorizing executives, the general practice in industry, as in government, is for those recommending the expenditures to make properly documented requests therefor.

Appropriation Request

The appropriation request is simply a document containing data and information necessary to enable decision by the proper authority on whether or not the request should be approved, and thus, whether or not the project it represents should go forward. When properly signed by the approving authorities, the appropriation request itself, or at least the sheet signed by the appropriators, automatically becomes the direct authority for others to carry out the proposals. Conversely, refusal signifies lack of concurrence in its proposal by the authorizing official or officials.

To round out its responsibility for *total* control of fixed capital, top management must, in addition to deciding on how funds for new plant and equipment are to be allocated, certify all other changes in existing capital facilities. Executive action in these other capital matters is also discretionary, and, as in the case of new expenditures, formal requests must be submitted to the authorizing officials.

CONTROL OF CAPITAL CHANGES

The chemical, petroleum, and related industries afford examples of businesses with dynamic fixed capital structures. They are constantly making large capital additions as mentioned in the foregoing paragraphs. Retirements and other capital changes also proceed at a notable rate, reflecting the influence on property of policies required to cope with process obsolescence, competition for markets, and other factors.

To visualize better the important role of appropriation requests in control of capital changes, an example can be found in the familiar situation wherein a number of proposed new expenditures, all of them deemed sufficiently important by their sponsors to have been written up in appropriation request form, are submitted to the proper officials with recom-

mendations for approval. It is safe to assume that these individual projects will have reached their advanced stage of consideration only by surviving screening processes at various management levels.

At this stage, by having available the documentation afforded by individual appropriation requests, the authorizing officials may perform further, and probably ultimate, screening. This would comprise either their approving or disapproving individual projects on the latter's merits per se, or weighing relative merits of various projects against one another, notably where the projects were competing for available capital. In this way, appropriation requests aid in conserving and controlling the flow of capital funds.

This assertion, furthermore, is essentially valid whether the appropriation requests being considered are ex-post-facto matters or "first-in-hand" presentations, because in either event the appropriation requests provide the information needed for an up-to-the-minute, current decision.*

PREPARATION AND HANDLING OF APPROPRIATION REQUESTS

The literature practically ignores the subject of appropriation requests, and the problem is left to individual companies to develop their own systems and procedures for preparing, handling, and reviewing these documents. In the process and related industries, engineers and chemists are heavily relied upon to develop and correlate data and information required for appropriation requests. However, it was suspected that, unlike the standardization that has been developed in so many areas of engineering, little uniformity exists in the field of appropriation request work. This suspicion was confirmed in a survey made of the appropriation procedures of approximately forty chemical, petroleum, pharmaceutical, and related companies of various sizes. One of the few evidences of uniformity was that practically all reported using standard forms and format for writing up appropriation requests. This is interpreted as reflecting the value placed on formal means for dealing with capital changes.

It is a widespread practice to maintain fixed capital requirement forecasts for a year or more, from which management may periodically select groups of projects and authorize them in blanket form as a capital budget. This is a planning function, and when individual projects from the budget come up for final authorization, the resulting appropriation requests are of the ex-post-facto type mentioned previously. Whether a capital forecast-budget system is employed, or whether all appropriation requests in a company are developed from scratch, the necessary information in all cases must be obtained and put together.

The projects covered by appropriation requests may be the brain-children of individuals or groups ranging from obscure departments to executive planning staffs. Once written up in final form, the important appropriation requests usually follow definite channels toward a final decision. Tables 1A and 1B contain a compilation of data obtained in the previously mentioned survey. It illustrates the degree of authority (measured dollarwise) vested at various corporate levels to authorize capital expenditures.

Depending on policy of the particular company, the central or parent officials may study and pass judgment on requests directly, or the requests may be sent first to an executive such as a vice president or comptroller, or to an executive, finance, or budget committee. These intermediaries may maintain staffs to review the requests as submitted. A system of this type provides checks and balances, and discourages or eliminates undesirable slipshod and informal practices in dealing with an important capital function. A sampling from the aforementioned survey discloses that fourteen companies reported having central departments for making final review of appropriation requests prior to executive action thereon, while eleven companies have no such department.

Boards of directors figure prominently as final authorizing agencies. (see Table 1B).

MAKE-UP OF REQUESTS

Appropriation requests serve their purpose most effectively if prepared to a high standard of completeness, accuracy, and readability. Nearly all the chemical, petroleum, and other companies surveyed reported use of standard forms for the various sections likely to be incorporated in appropriation requests, and also the use of a standard format for assembling the components.

Usually, a simple paper binder will suffice as a cover. If the main forms used are printed on thin, durable paper, the approved requests can be bound into compact permanent files. Since appropriation requests are themselves important instruments of communication, they should be written in unambiguous style, slanted away from involved technical considerations, and toward a down-to-earth dollars-and-cents approach. By the time a major project has reached the appropriation request stage, it has presumably gone through much technical and economic evaluation and appraisal, including detailed engineering studies. The concentration and refinement of all this work, however, expressed in lucid and straightforward terms, are the requirements for drawing up important appropriation requests. Small requests should also conform to this high standard.

It is possible to back up appropriation

* The term "ex-post-facto" requests covers those projects that had received prior executive approval in principle or under a budget authorization. The second category would be capital projects that the authorizing officials were being apprised of for the first time.

Table 1A.—How 35 Selected Chemical and Related Companies Delegate Power to Authorize Appropriation Requests.

Maximum amount of individual appropriation request	Number of companies permitting authorization by: Officers and committees of officers	Non-officers
$ 1,000	1	4
2,500	1	5
5,000	—	5
10,000	3	3
25,000	5	2
50,000	2	—
100,000	1	—
250,000	5	—
Unlimited	17	—

Table 1B.—Mandatory Participation by Boards of Directors in Approving Appropriation Requests.*

Amount of individual appropriation request, above which board approval is required (lower categories not repeated)	Number of companies requiring board action on individual appropriation requests
Under $10,000	2
10,000	3
25,000	5
50,000	2
100,000	1
250,000	5

* Some companies as in Table 1a.

requests with supplemental volumes or reports, but this seems hardly necessary if the requests themselves are carefully prepared. Also, such supplemental material is likely to be bulky and become separated from the appropriation requests themselves, which may make subsequent references and check-ups difficult.

To illustrate, qualitatively, the contents of appropriation requests, a composite request outline incorporating some information obtained in the survey previously mentioned, is presented below. It is assumed that the necessary paper forms would be printed with standard wording, lining, columnar divisions, as required. This composite breaks down as follows:

Title Sheet

The title sheet would normally include the title and any serial numbers assigned to the project; the amount and location of the capital change covered and by whom submitted; date submitted and estimated date of completion if approved; and name and title of authority to whom the request is directed.

Master Sheet

A single page, with necessary standard wording affording, when filled out, a concise recapitulation of the project covered will suffice for master sheet. On this sheet some data on the title page may be repeated such as numbers, dates, and names. Provision should be made for reporting a brief description of the project on a few lines, and a similarly brief rundown of the benefits and results expected from the capital changes requested. If an accounting recapitulation is included of the expenditures, retirements, transfers, or other capital changes involved, this page will give a good thumbnail sketch of the whole project, even if the latter is quite large.

Sheets for Body of Text

Practically all appropriation requests will include some descriptive text, long or short, depending upon the importance of the project. The blank sheets for this part of the appropriation request may be essentially free of standard print, except as desired to provide continual identification of the project described. The main subheadings for material presented in this text may include the following, probably appearing in about the order listed:

1. Background—adequate story of the project or change requested, including all pertinent historical and current information necessary for complete understanding of the proposal.
2. Change Planned—description of the construction, retirement, or other changes proposed, including total cost, how the changes will be made and how they will affect the existing capital setup and other important items, such as product capacity, if involved.
3. Explanation—a convincing account of the necessity and reasons for making the proposed changes. If discussion is desired of alternatives, such should be included. However, since presumably the project written up is the one of choice after careful screening, discretion may be needed in discussing alternatives, in order to avoid confusion.

   Explanation would also include a well-spelled-out description of benefits, both monetary and other, projected as a result of the proposed changes. Often, success or failure in obtaining an appropriation will depend on how clearly and realistically the benefits section is presented.
4. Special Sections—to include headings not used ordinarily in average requests, but required or desirable in justifying certan types of capital change proposals. They would involve such adjuncts as photographs, drawings, and maps; a patent statement giving legal interpretation on unfamiliar products or processes; itemized unit production costs for new or expanded products; and detailed payout or investment return calculations. Ordinary payout information is favored for inclusion in the explanation heading. The detailed type of rendition for production costs and payouts can be standardized, and reported on separate forms if desired. In any event, they would supplement the information presented under the explanation heading.

Cost Estimate Sheets

Cost estimate sheets usually form the most arithmetically detailed section of a major appropriation request. As in the case of the sheets used for the body of the text, the blank estimate sheets may be largely free of letter-press, but will commonly contain appropriate columns and column headings for listing in detail the expenditures for construction, relocations, transfers, dismantlements, or other work involved in the request. For convenience, retirements of capital facilities are usually reported separately on similar sheets with appropriate columns and headings.

A few miscellaneous statements about appropriation requests should be made here:

By proper combination of the individual standard forms, capital changes ranging from small and simple ones to complex projects can be adequately written up. Small jobs can, if desired, be consolidated in blanket form.

Since most appropriation requests covering capital expenditures contain, at best, only estimates of the costs involved, the actual costs of the completed projects will not coincide with the authorizations. If actual cost exceeds the estimate, a supplemental or deficiency request is usually needed, redefining the expenditure. The same standard forms can be used for supplemental requests, and it is not unknown for two or more such requests to be required before some projects are completed.

If deficiency requests become epidemic, well-kept files of approved appropriation requests can sometimes provide management with clues to reasons for jobs' being underestimated. Consistently occurring major underruns also may be checked in this way. Analogous to this reference use of appropriation request files is their value as a source of construction and other cost data. It may sound strange, but accurate, readily available cost data are not as abundant as most engineers would like. Thus, appropriation request files can be excellent cost handbooks, when used within proper limits.

Information in appropriation requests on benefits and payouts can have continuing reference value. The survey referred to earlier disclosed that most process industries make provision for checking with later actual results the performance of projects estimated at the time of their approval. A usual time for initial appraisal appears to be about one year after project is completed and/or in normal operation. In some cases, where the first appraisal is unsatisfactory, periodic additional checks are made until projected results are achieved; in other cases, appraisals are dropped after elapsed periods such as three or five years.

The survey disclosed that few engineers are employed substantially full time in preparation or review of appropriation requests. However, they participate in large numbers in the general work, mainly in providing background information and preparing construction cost estimates and economics data. Engineers can contribute with increasing significance to the function described in this article: namely, control of fixed capital and protection against its misuse. Such participation will be encouraged if sufficient importance is attached to the work to stimulate active engineering interest.

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INTEREST RATE OF RETURN for capital expenditure evaluation

How does one decide whether or not to invest in a new chemical plant? Most companies relate average expected profits directly to the investment required and express the result as a fractional rate of return or a payout. Rate of return is the percentage of investment returned as profit each year, while the payout is the number of years required to recover the investment in the form of revenue.

Construction may be time consuming, sales may be expected to limp along and then skyrocket, additional working capital may be necessary at irregular intervals. How can the estimator allow for the effect of time on cash fluctuations?

The method proposed here conceives of profits as interest on the investment, and relates the average profit to the average funds committed over the life of the plant, including original capital outlays plus interest obligation incurred. The *interest rate of return* proposed here makes allowance for all the vagaries outlined above and thereby provides an accurate single measure of profitability.

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The capital-expenditure evaluation program is vital since such expenditure decisions are the key to company growth and since funds are irretrievably committed by such decisions. It is generally accepted in the chemical and petroleum industries that profits should be related to investment, rather than, for instance, to sales, but various methods exist for relating profit to investment. The chemical industry seems to utilize chiefly the following two methods:

1. Return on original investment or engineer's method—The ratio of the average annual profit, over the earning life only, to the gross investment in fixed and working capital.

2. Return on average investment or accountant's method—The ratio of the average profit, over the earning life only, to the average investment on the company's books over the same period.

In these methods, because of averaging of profits over the earning life of projects, no change in return results, regardless of the timing of receipt of these profits, as long as the total profit is the same. In the examples described later, changes in income pattern, which result in variations of 30% in the *interest rate of return*, do not result in any changes in these more common rates of return.

A third method for evaluating capital expenditures seems to be in common use by the petroleum industry.

3. Payout time or cash recovery period—The number of years required to recover depreciable fixed investment from profits and depreciation accruals.

Method No. 3 has an obvious advantage over the other two in that it recognizes, for the initial period at least, the timing of receipt of the funds. It suffers from the shortcoming that neither the timing nor the amount of the proceeds from the project is considered at all after the payout period although this period is seldom as much as half the expected useful life of the equipment.

This paper describes a more inclusive relationship between profit and investment which properly considers the timing of receipts and expenditures over the entire project life.

4. Interest Rate of Return on Investment—The average rate of interest earned by the project for the company, on the company's outstanding investment in the project. Stated another way, it is the rate of interest at which the company's investment is repaid by proceeds of the project.

> **The consideration of compound interest in capital expenditure evaluation is not new; references to its use have been found as far back as 1887 (*23*). It is a basic tenet of sound texts in engineering economy (*5, 18, 21*). The authors are indebted for their introduction to this method to H. G. Hill, Jr., and J. C. Gregory (*6, 9*). Numerous publications have developed the technique much as presented in this paper (*2-4, 14-15, 17, 20*). However, only one brief to the technique has been found in the chemical literature (22) and admittedly limited information indicates little application of the technique by industry. It is the authors' purpose to popularize and perhaps to add something to the interpretation of this concept of interest as a rate of return in the field of chemical engineering. Jelen (*10, 11*) utilizes compound interest in replacement analysis and Happel (*7*) includes interest in a modified payout time determination. Differing techniques for utilizing the same broad concept have also appeared (*8, 13, 16, 24*).**

It is the maximum rate at which funds could be borrowed by the company, for investment in the project, and have the project break even at the end of its expected life. It is the ratio of the average profit, over the entire investment period, to the average investment by the company in the project, including interest accruals.

The first two methods for rate of return evaluation referred to previously indicate the yearly fraction of an investment recovered by an average profit. The percentages obtained may be regarded as fractional rates of return, not to be compared directly with the interest rate of return. This distinction has, in fact, brought about the adoption of the term *interest rate of return*. It is with some hesitation that this new name is introduced for an established procedure. However, it was thought that the existing terminology (*investor's method, discounted cash flow method, Profitability Index*) lacked a simple descriptive phrase which identified the main feature of the method—interest—and was readily associated with capital expenditure evaluation—rate of return.

Interest Rate as an Evaluation Method

When money is borrowed from a bank, the fee paid for the use of the bank's funds is expressed as an interest rate. The bank is paid this fee because its funds are being used temporarily in some way which is worth more to the borrower than the interest penalty he is paying.

The bank can evaluate opportunities for investment of its funds by compar-

ing interest rates which these opportunities provide. In the same way, a company can evaluate the various investment alternatives for use of its money in terms of the interest rate obtainable. Consider the company and the project as separate entities so that one (the company) invests the funds needed to operate the project, while the other (the project) utilizes these funds so as to repay the company, by the end of the project, all the funds invested, plus a profit. This profit can, as for the bank loan, be expressed as an interest rate which the project pays the company over its life.

Since profits are considered as the service charge paid by a project for the use of a company's funds, the problem then can be expressed as that of determining the rate of interest at which the company's investment is repaid by proceeds of the project. In a computation of thsi rate, interest accumulated over each interest, or compounding, period is added to the principal at the beginning of the period to obtain the new principal for the next period. This is the essence of compound interest. The term *obligation* has been adopted to cover this changing sum, to avoid confusion with the original principal sum. Throughout this paper obligation denotes the total indebtedness of the project to the investor, including all capital outlays and accrued interest at a given time.

Interest rate of return expresses profits as an interest rate which is earned, on the average, by the investment over the project life. This may sound like the ***return on original investment*** defined above. There is a significant difference, however, since by this interest-rate-of-return method the average profits are related to the obligation as just defined—the average investment outstanding in the project including interest obligation, which is a different sum. The initial investment in fixed and working capital is not the maximum investment which a company really has in a project if it is agreed that the project must regularly accept an interest charge on the total funds utilized. Since a project is often slow in earning money when it starts and since the investment by the company in the project is accumulating interest obligation from the moment the first dollar is spent, the point of maximum obligation is frequently later than start-up, that is, during the first few years of the project.

The original outlay is made for the purpose of securing a series of future payments which will exceed the original amount of the outlay. The interest rate of return, representing the profit, is then that rate which, when deducted according to compound interest rules from this future series of net receipts, makes them equal to the initial outlay. This deduction of interest is known as *discounting* and determines the *present value* * of these future receipts at a

* See Appendix.

Table 1.—Investment Schedule for Sample Cases A, B and C

Time	Item	Investment, (dollars in thousands)		
One year before start-up	land	5		
Uniformly over 1st year before start-up	plant	55		
Start-up	working capital	10		
Sub-total, original capital outlay			70	
Five years after start-up	recover land value	(− 5)		
	recover scrap value	(− 5)		
	recover working capital	(−10)		
Subtotal, capital recovery			(−20)	
Total depreciable value				50

Table 2.—Development of Cash Receipt Schedules for Sample Cases

(Dollars in Thousands)

Year	Investment	Sales	Costs excl. depreciation [1]	Depreciation	Total costs	Income before tax	Profit after 50% tax	Cash receipts [2]
Case A—sales constant								
−1	5							(− 5)
−1 to 0	55							(−55)
0	10							(−10)
1st		100	50	10	60	40	20	30
2nd		100	50	10	60	40	20	30
3rd		100	50	10	60	40	20	30
4th		100	50	10	60	40	20	30
5th		100	50	10	60	40	20	30
End 5th	(−20)							20
Total	50	500	250	50	300	200	100	100
Case B—sales increasing								
−1	5							(− 5)
−1 to 0	55							(−55)
0	10							(−10)
1st		60	30	10	40	20	10	20
2nd		80	40	10	50	30	15	25
3rd		100	50	10	60	40	20	30
4th		120	60	10	70	50	25	35
5th		140	70	10	80	60	30	40
End 5th	(−20)							20
Total	50	500	250	50	300	200	100	100
Case C—sales decreasing								
−1	5							(− 5)
−1 to 0	55							(−55)
0	10							(−10)
1st		140	70	10	80	60	30	40
2nd		120	60	10	70	50	25	35
3rd		100	50	10	60	40	20	30
4th		80	40	10	50	30	15	25
5th		60	30	10	40	20	10	20
End 5th	(−20)							20
Total	50	500	250	50	300	200	100	100

[1] Costs excl. depreciation @ 20% fixed, 80% variable.
[2] Profit after tax + depreciation − investment.

Table 3.—Repayment of Project Obligation

(Dollars in Thousands)

Year	Opening balance: opening value	Opening balance: compounded value [1]	Cash receipts: value as received	Cash receipts: compounded value [2]	Cumulative cash receipts after interest (unpaid obligation): year end	Cumulative cash receipts after interest (unpaid obligation): avg.
	A	B	C	D	E = (B + D)	F = (A + E)/2
Case A—Sales Constant Profit (or Interest) at 31%						
−1			$(− 5)	$(− 5)		
−1 to 0	$(− 5)	$(− 7)	(−55)	(−64)	$(−71)	$(− 38)
0	(−71)	(− 71)	(−10)	(−10)	(−81)	
1st	(−81)	(−110)	30	35	(−75)	(− 78)
2nd	(−75)	(−102)	30	35	(−67)	(− 71)
3rd	(−67)	(− 91)	30	35	(−56)	(− 61)
4th	(−56)	(− 76)	30	35	(−41)	(− 48)
5th	(−41)	(− 55)	30	35	(−20)	(− 30)
End 5th	(−20)		20	20	0	
Total (6 yr.)			100 } [profit]*			(−328)
Avg.			17 }			(− 54)*
Case B—Sales Increasing Profit (or Interest) at 27%						
−1	$(− 5)	$(− 7)	$(− 5)			
−1 to 0	(−70)		(−55)	$(−63)	$(−70)	$(− 37)
0	(−80)	(−108)	(−10)		(−80)	
1st	(−82)	(−107)	20	23	(−82)	(− 81)
2nd	(−78)	(−103)	25	29	(−78)	(− 80)
3rd	(−69)	(− 90)	30	34	(−69)	(− 74)
4th	(−50)	(− 64)	35	40	(−50)	(− 60)
5th	(−20)		40	46	(−20)	(− 35)
End 5th			20		0	
Total (6 yr.)			100 } [profit]*			(−367)
Avg.			17 }			(− 61)*
Case C—Sales Decreasing Profit (or Interest) at 35%						
−1	$(− 5)	$(− 7)	$(− 5)			
−1 to 0	(−73)		(−55)	$(−66)	$(−73)	$(− 39)
0			(−10)		(−83)	
1st	(−83)	(−117)	40	48	(−69)	(− 76)
2nd	(−69)	(− 98)	35	42	(−56)	(− 62)
3rd	(−56)	(− 79)	30	38	(−43)	(− 50)
4th	(−43)	(− 61)	25	30	(−31)	(− 37)
5th	(−31)	(− 44)	20	24	(−20)	(− 26)
End 5th	(−20)		20		0	
Total (6 yr.)			100 } [profit]*			(−290)*
Avg.			17 }			(− 48)

[1] See Table 6; Factor as shown below for cash flows which occur "In an Instant One Year Before" since "Opening Balance" is available for entire year.

[2] See Table 6; Factor as shown below for cash flows which occur "Uniformly until zero time from 1 year before," since cash receipts assumed uniform over year.

Case	A	B	C
Rate	31%	27%	35%
Factor 1	1.36	1.31	1.41
Factor 2	1.17	1.15	1.19

* Alternative calculation for interest rate of return:

Av. Profit (Col. C) / Av. Obligation (Col. F)	Case A	Case B	Case C
	17/54 = 31%	17/61 = 27%	17/48 = 35%

given interest rate. In terms of the borrower-lender relationship, the interest rate of return is the maximum rate at which money could be borrowed, invested in a project, and just repaid with interest at the given rate, as of the end of the project.

The method proposed herein permits evaluation of alternative investments while considering all variations expected in time patterns of cash expenditure and receipt, and supplies the profitability prospects as single interest rates of return. It allows for the difference in profitability between one plant, acquired ready to operate immediately, and another requiring the outlay, over, say, two years, of construction funds totaling exactly the same amount, all other factors being equal. It reflects the advantage of accelerated depreciation allowances, such as sum-of-the-years-digits.

In general, the method permits evaluation of capital projects without any increase in experimental or random errors already present in the development of process design, market forecasts, and the like. An overriding advantage of methods allowing for the time value of money is the discipline imposed, in that it forces detailed consideration of expected performance over the project life. The method makes it less likely that the estimator can enjoy the perilous luxury of generalized forecasts of average sales, costs, and profits.

Interest is commonly expressed as payments at agreed intervals, usually a year, although shorter periods of time are used. J. C. Gregory (*6*) has outlined a concept of interest payment which seems to approximate closely the general pattern of business transactions. In most businesses, money payments occur almost continuously so that the net receipts or compounding of interest can be approximated as occurring in terms of an infinitesimal interest period. The effect of this continuous compounding, compared with annual compounding, is discussed in the Appendix.

Illustrative Sample Cases

Three sample cases have been prepared to illustrate the steps required to obtain solutions and, more important, to permit examining the significant effect of considering the time value of money. These examples will serve also to compare the other methods of indicating profitability with the interest rate of return. In developing these cases, an attempt has been made to include most of the common investment and profit variations, while at the same time minimizing the detail work necessary to obtain a solution. The sample cases are not intended to be representative of any specific product or process, but are deliberately established with extreme patterns and life expectancies for purposes of illustration. They depict the response of the interest rate of return to varying time profiles of cash receipts, that is, to the time value of money.

In Table 1, an investment schedule has been outlined for all three cases. Each project has been assumed to have a five-year life, after which time the plant is shut down, equipment scrapped, working capital liquidated, and land sold, with a capital recovery of $20,000. A depreciable plant value of $50,000 is recovered over the five-year life.

In Table 2, cash receipts schedules have been developed for the three cases. The qualification of cash applied to net receipts is important since all transactions affecting cash position are considered in this method of evaluation, including depreciation accruals. Depreciation has been taken on a five-year straight-line basis for simplicity. Other costs were assumed 50% fixed and 50% variable. A 50% income tax rate has been assumed. The final column, cash receipts, indicates the net effect of cash flowing into and out of each project throughout its life. It shows the initial capital outlays, the cash income (profits after tax plus depreciation accruals), and finally the recovery of cash through the sale of scrap equipment, land, and liquidation of working capital. The total of this column represents the profits realized.*

CASE A—SALES CONSTANT

To emphasize the meaning of interest rate of return, a completed calculation at a 31% interest rate of return is shown in Figure 1. The graph represents the cash position of the company through time; the area below zero dollars indicates money owed by the project to the company, and the area above represents profit to the company. The solid line reflects accumulation of cash receipts of the project throughout its life, before a consideration of interest. One year prior to the start-up of the plant (start-up assumed at zero time), a cash outlay of $5,000 for land occurs, as shown in Table 1, followed by the expenditure over the succeeding year of $55,000 for construction of the plant.

This $60,000, plus the additional outlay of $10,000 for working capital instantaneously at the start-up of the plant, then brings the total (and maximum) cash position before interest to $70,000. As the plant goes into operation, income from production and sale of the output reverses the direction of the solid cash-position-before-interest line. By the end of the five-year life of the project, these cash receipts provide a cumulative positive cash position, before interest, of $80,000. At this point, liquidation of the working capital, land, and scrap value of the equipment provides an additional $20,000 cash, so that a final positive cumulative cash position, before interest, of $100,000 is obtained. Provision has been made for repayment of all the initial capital outlays, so that the $100,000 positive balance actually indicates the total profit of the venture over its life.

Analysis of Project Obligation through Time

On the assumption that the $100,000 profit has been expressed as an average 31% interest over the project life, interest obligation begins to accrue as soon as the first cash outlay is made. The broken line on Figure 1 indicates the project's cash position after providing for the obligation to pay 31% interest. As soon as the project begins to generate cash, these receipts are, in effect, turned back to the company immediately, and go toward payment, first of total interest accruals, and then any residual amount toward repayment of original principal. The broken line shows the progress which the project makes in repayment of its total obligation, finally rising to zero (no obligation) at the end of the fifth year. The vertical difference between the solid and broken lines at any time equals the accrued interest (profit due the company) up to that time.

Since an understanding of the broken

Interest Rate of Return

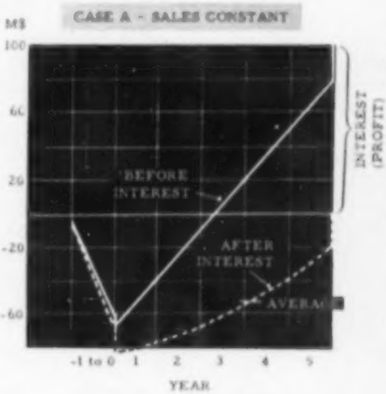


Fig. 1. Analysis of project proceeds—cumulative cash receipts.

*** Note: the transactions at year —1 and 0 are instantaneous; all receipts listed are assumed uniform over the year shown, except the final cash recovery at the end of the life, assumed instantaneous. In all three cases total investment, total sales, total costs, total profits after tax, and total cash receipts are equal before consideration of interest. Yearly sales vary as indicated.**

line is essential, its derivation has been detailed in Table 3. Starting with the opening balance in col. A, an interest factor is applied (1.36—see footnote 1 in Table 3) which compounds the opening balance through the year to yield a year-end value as in col. B. Interest is applied to cash receipts at the same percentage rate, although since these receipts come in evenly over the year, and therefore are not all compounded for the entire year, a compounding factor of 1.17 (footnote 2) is applicable. The net effect of the compounding of the opening balance, as indicated by col. B, and the credit for compounded cash receipts, as indicated by col. D, is shown in col. E, the net year-end obligation. This amount is also the opening balance of obligation for the next year. The average obligation over the year (col. F) is the arithmetical average of the opening and year end balances of obligation.

At year −1, the project owes the company $5,000, which, compounded continuously at 31% interest, cumulates to $7,000 by the end of the year. (The project incurs $2,000 more obligation, an additional amount of money owed to the company.) During the year the company invests $55,000 cash in the project which again is compounded, to a value of $64,000 by the end of the year. Summing these, the project owes $71,000 at time zero. Working capital of $10,000 is then required, so the project starts operation (first year) with a total obligation of $81,000. Col. B shows this $81,000 compounded to the end of the first year, as $110,000, which the project would have owed if no receipts had come in over the first year ($29,000 new interest obligation). However, receipts were $30,000, and the compounded value, $35,000, is credited toward repayment of obligation. Since the $35,000 credit exceeds the $29,000 interest accrued on the $81,000 opening balance, the year-end balance is reduced to $75,000.

Similarly, each succeeding year the compounded project receipts more than offset the interest due on the opening balance until, at the end of the fifth year, a balance of $20,000 remains. This amount is assumed instantly recovered from liquidation of land, scrap value, and working capital, so the project has no unpaid obligation to the company at the end of the five years. All profit has been paid back to the company as the 31% interest rate, in addition to repayment of the original investment, which satisfies the definition of ***interest rate of return*** at the assumed 31% interest rate.*

The interest rate of return has also been defined as the ratio of average profit to average obligation. As a footnote to Table 3, the averages shown in cols. C and F are expressed in this form, yielding the 31% interest rate. Profit is averaged over *six* years, including the 1-year construction period.

The above description attempts to clarify the significance of the interest rate once it has been calculated, by permitting study of the project obligation as it moves along in time. This many-step procedure might be used for determining the interest rate of return, by repeated trial and error. There is a simpler method of applying the same principles, so that the above analysis is not essential to the solution.

Solution by Present-Value Technique

In Table 3 only single-year compounding of all transactions during the life of the project was used. Therefore, only two compounding factors were needed, one for amounts compounded over a full year and another for amounts compounded as received over the year. Over longer periods of time, similar interest factors can be used to express the value of past or future cash transactions, at any specified *zero* or base time and any given interest rate. Compounding adds interest to transactions occurring before the zero time; discounting deducts interest from transactions occurring after the zero time. Use of these factors converts all transactions to a value at zero time, known as *present value* or *present worth*. The effect of applying interest in this manner is still that of terminating the project life with no net balance of obligation after payment of interest. (Further discussion of the term *present value* is contained in the Appendix.)

In Table 4 an analysis has been developed on the present-value basis. This analysis shows the method by which the 31% interest rate of return, used in Figure 1 and Table 3, was obtained. The problem may be stated as that of finding the interest rate which, when applied to the series of cash transactions, before and after time zero, will balance exactly the cash outlays with the cash receipts, as of time zero. The solution is obtained by trial and error, usually by two brief series of calculations.

Trial Rate.—By experience, it was found that a good trial rate with which to start is the even 5% closest to 1¼ times the percentage which the average profit is of the total capital investment. The average profit is taken over the entire number of years between the start of expenditure and termination of the project—six years in this case. The trial rate here is 30%.

The present-value factors shown under the 30% rate are taken from Table 6, a continuous interest table, which is discussed in the Appendix. These factors represent the zero-time value of a dollar at 30% interest if spent or received at the time shown in the left-hand column. The interest factor is multiplied by the cash receipt for that particular time and a present value obtained.

An interest rate is sought which will reduce the value of expected cash receipts to a zero-time value equal to the total of the compounded expenditures (−$81,000). For the first year, at 30%, cash to be received uniformly over the year has a present value of only 0.86 of face value. Therefore the $30,000 receipts over the first year have been discounted at 30% and a present value of $26,000 has been obtained. This same procedure is followed for the remaining life of the project. Each discounted value represents the contribution of the cash receipt to repayment of the total project obligation at time zero.

Summing up the present values in the 30% column a positive net balance of $1,000 is obtained, which indicates that future receipts were not discounted at quite a high enough rate to balance the compounded cash outlays. Therefore, the rate 5% higher is chosen, 35%, to make the second trial calculation shown. This more severe discounting results in a negative present value balance of $9,000, indicating that future receipts were discounted at too high an interest rate. The solution rate is obtained, as shown, by interpolating arithmetically between these two dollar values.

For unusual cash flow patterns, more than two trials may be necessary. The residual present value always indicates the direction in which the next trial should be made since increased discounting lowers the present value.

CASES B AND C—SALES CHANGING

Recall that all three sample cases were set up with identical investment patterns, total sales, total costs, total

*** Happel (8) and Winn (24) have claimed that the system, recommended by Dean (2-4) and herein, requires reinvestment of project earnings at the interest rate of return achieved on the project. It is the authors' belief that the analysis shown in Figure 1 and Table 3 makes clear that no reinvestment of profits at any interest rate is involved. The profits are converted entirely to interest payments which are then repaid the company and no further cognizance taken of them. Only the obligation of the project to the company is compounded. Since the interest rate of return is calculated to reduce the obligation exactly to zero at the end of the project life, some obligation normally exists throughout the project life.**

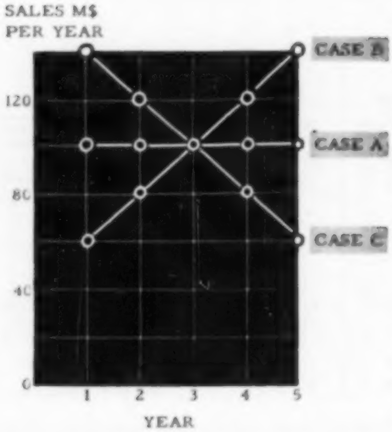


Fig. 2. Sales patterns for sample cases A, B, and C. A—sales constant. B—sales increasing. C—sales decreasing.

profits, and project life. Figure 2 indicates the important variable of sales patterns which will be explored in Case B, representing an increasing sales pattern, and C, representing a decreasing sales pattern.

Figure 3 shows the analysis of project proceeds for Cases B (increasing sales) and C (decreasing sales) in a manner similar to the analysis of Case A in Figure 1. Looking first at the solid lines of cash position before interest, the effect of the lower receipts in the early years for Case B and the higher receipts in early years for Case C can be seen. Before interest, in Case B, a zero cumulative cash position is not obtained until near the end of the third year, whereas in Case C this same position is obtained near the end of the second year.*

Recall that the broken line depicts cash position after accrual of interest obligation. In Case B, for which a 27% interest rate has been obtained by the method previously illustrated, the broken line indicates that cash receipts are insufficient to meet the additional interest obligation accruing during the first year of operation of the project. Hence, at the end of the first year a less favorable cash position of approximately $82,000, after application of interest, is obtained, as compared with a position of $80,000 at the beginning of this same year. It is not until the second year that sufficient cash receipts are obtained to overcome the interest accruals and receipts begin to reduce the accumulated obligations of prior years. Note the shape of this curve in contrast to Case C.

Case C shows a sizable reduction during the first year of operation in previously accrued obligation in addition to paying off that year's interest obligation. A sizable difference in unpaid obligation is obtained between the two cases, with Case B averaging over its life about $59,000, and Case C averaging about $49,000 for the same period.

To return to Table 3: the year-by-year repayment of interest or profit obligation of Cases B and C is shown there. Although different interest rates are used in each case, the interest rate of return in each case reduces the obligation to zero after five years and provides for payment of all profits as interest. At the bottom of each portion of the table is shown the alternative calculation of the interest rate of return.

In Table 4 present value solutions are also detailed for Cases B and C. For Case B the first trial rate is again 30% and the present value factors are the same as in Case A, but cash receipts are lower in the earlier years when less discounting must be applied. Therefore, the total present value at 30% is negative (−$8,000) whereas a positive total present value is obtained with a 30% rate in Case A. The solving interest rate for Case B must be below 30% and a 25% trial rate is used to bracket the solving rate of 27%. Case C falls between 30 and 35% as did Case A, but the higher early-year receipts result in a solving rate much closer to 35%.

Interest Rate of Return

Why does Case C yield the highest return? If the conditions are attained as assumed, that is, if circumstances were actually expected to bring about the abandonment of each project at the end of the indicated five-year period, the higher early income of Case C returns the company's outlay earlier than Case A and much earlier than Case B. The time value of these earlier receipts is reflected in the higher interest rate of return. Case C yields a return of 35%, compared with Case A at 31% and Case B at 27%.

Comparison with Other Evaluation Methods

Table 5 compares the results described above on these sample cases with the results of evaluation by the other methods defined at the beginning of this paper. The original investment method and the average book method both show the same return on investment for all three sample cases, because of their averaging of profits which does not reflect changes in the time pattern of income. These methods ignore the construction period in averaging of profits and in determination of average book investment. For projects in which investment and income

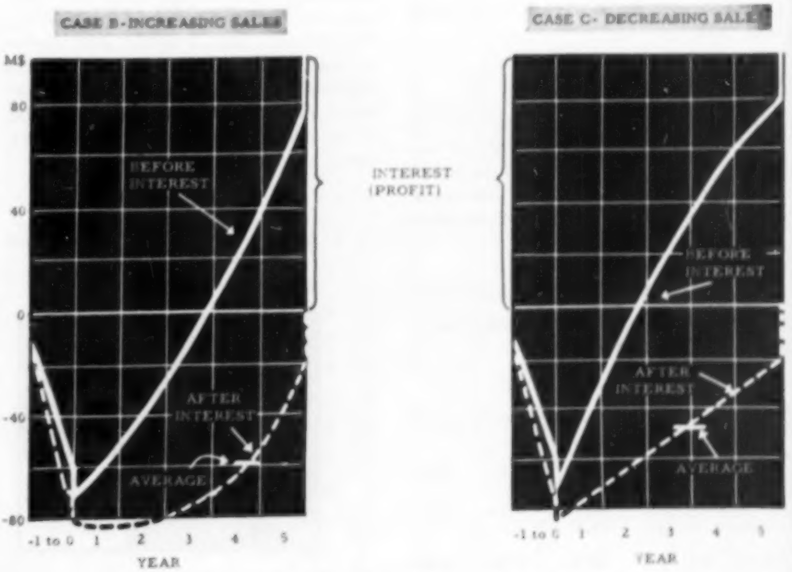


Fig. 3. Analysis of project proceeds—cumulative cash receipts.

* These points can not be considered as payouts since the instantaneous liquidation of working capital, land value, and sale of scrap would permit complete recovery of the initial capital outlay prior to these points.

Table 4.—Present-value Solution for Interest Rate of Return

(Dollars in Thousands)

Year	Case A—Sales Constant: cash receipts	@ 30% rate: factor	@ 30% rate: present value	@ 35% rate: factor	@ 35% rate: present value
—1	\$(— 5)	1.35	\$(— 7)	1.42	\$(— 7)
—1 to 0	(—55)	1.17	(—64)	1.20	(—66)
0	(—10)	1.00	(—10)	1.00	(—10)
1st	30	.86	26	.84	25
2nd	30	.64	19	.59	18
3rd	30	.47	14	.42	13
4th	30	.35	11	.30	9
5th	30	.26	8	.21	6
End 5th	20	.22	4	.17	3
Positive totals	170		82		74
Negative totals	(—70)		(—81)		(—83)
Total	100		1		(— 9)

Interpolating over 5 percentage points:

$$R = 30 + 5\left(\frac{1}{1+9}\right) = 30 + 0.5 = 30.5 \text{ or } 31\%$$

Year	Case B—Sales Increasing: cash receipts	@ 30% rate: factor	@ 30% rate: present value	@ 25% rate: factor	@ 25% rate: present value
—1	\$(— 5)	1.35	\$(— 7)	1.28	\$(— 6)
—1 to 0	(—55)	1.17	(—64)	1.14	(—63)
0	(—10)	1.00	(—10)	1.00	(—10)
1st	20	.86	17	.88	18
2nd	25	.64	16	.69	17
3rd	30	.47	14	.54	16
4th	35	.35	12	.42	15
5th	40	.26	10	.33	13
End 5th	20	.22	4	.29	6
Positive totals	170		73		85
Negative totals	(—70)		(—81)		(—79)
Total	100		(— 8)		6

$$R = 25 + 5\left(\frac{6}{8+6}\right) = 25 + 2.1 = 27.1 \text{ or } 27\%$$

Year	Case C—Sales Decreasing: cash receipts	@ 30% rate: factor	@ 30% rate: present value	@ 35% rate: factor	@ 35% rate: present value
—1	\$(— 5)	1.35	\$(— 7)	1.42	\$(— 7)
—1 to 0	(—55)	1.17	(—64)	1.20	(—66)
0	(—10)	1.00	(—10)	1.00	(—10)
1st	40	.86	35	.84	34
2nd	35	.64	23	.59	21
3rd	30	.47	14	.42	13
4th	25	.35	9	.30	7
5th	20	.26	5	.21	4
End 5th	20	.22	4	.17	3
Positive totals	170		90		82
Negative totals	(—70)		(—81)		(—83)
Total	100		9		(— 1)

$$R = 30 + 5\left(\frac{9}{9+1}\right) = 30 + 4.5 = 34.5 \text{ or } 35\%$$

time patterns are similar, either of the above methods does assist in rating the relative merits of projects.

The payout time rates the three cases in the same order of desirability as does the interest rate of return. However, performance beyond the payout period is ignored, so usefulness of this measure is limited. Sample cases were not designed to show up this major shortcoming of the payout time, but it is apparent that a case could be set up, like Case A, but terminating all income after exactly 1.7 yrs. Such a case would show no difference in payout time from Case A, but would show a zero interest rate of return.

Furthermore, the payout time gives no basis for comparison of the return from a project with the cost of obtaining capital. When calculated in addition to the interest rate of return, the payout time does provide a useful indication of liquidity, that is, a measure of the time required to reconvert fixed assets into cash.

Limitations

Since much has been described on what this system will do, some of the things it will not do should be stated here. Rate of return, one of the essential components of a capital expenditure evaluation program, must be complemented by knowledge of the cost of capital; supply of and demand for capital and its relation to desired rate of expansion; evaluation of technological, market, and other risks; residual values, such as markets to be exploited following the completion of the immediate investment problem; and so forth. The interest rate of return cannot eliminate the necessity for judgment, but it can narrow the area where judgment must be applied, by providing an accurate analytical method.

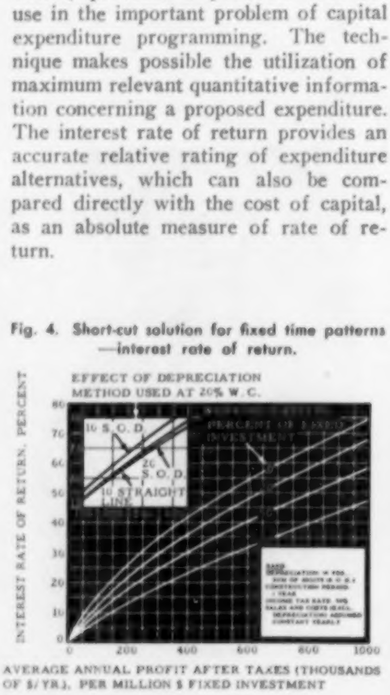
Table 5.—Comparison of Evaluation Methods

CASE	A	B	C
Sales	Const.	Incr.	Decr.
Method			
Original investment	29%	29%	29%
Avg. book investment	45%	45%	45%
Payout time, yr.	1.7	2.2	1.3
Interest rate	31%	27%	35%

Conclusions

To sum up, recognition of the time value of money, expressed as a uniform interest rate of return on money invested, provides a powerful tool for use in the important problem of capital expenditure programming. The technique makes possible the utilization of maximum relevant quantitative information concerning a proposed expenditure. The interest rate of return provides an accurate relative rating of expenditure alternatives, which can also be compared directly with the cost of capital, as an absolute measure of rate of return.

Fig. 4. Short-cut solution for fixed time patterns —interest rate of return.



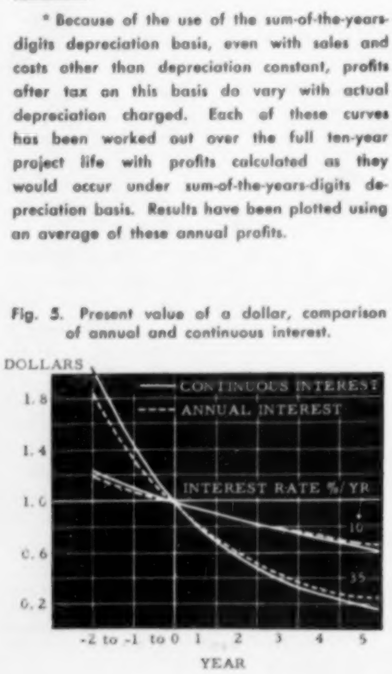
Appendix

SHORT-CUT FOR FIXED-TIME PATTERNS

Short-cut solutions may be established, as in Figure 4, if numerous projects, having certain common characteristics, are involved. Where sales and costs other than depreciation are assumed to be constant over the life of the project, where a common project life may be assumed, and where construction of facilities requires a common period of time, it is possible to prepare a single graph of all such interest-rate-of-return solutions. In Figure 4, with sales constant yearly, depreciation on a sum-of-the-years-digits basis over 10 years, a one-year construction period, and an income tax rate of 50%, interest rate of return is plotted against the average annual profit after taxes* per million dollars of

* Because of the use of the sum-of-the-years-digits depreciation basis, even with sales and costs other than depreciation constant, profits after tax on this basis do vary with actual depreciation charged. Each of these curves has been worked out over the full ten-year project life with profits calculated as they would occur under sum-of-the-years-digits depreciation basis. Results have been plotted using an average of these annual profits.

Fig. 5. Present value of a dollar, comparison of annual and continuous interest.



fixed investment. Results are shown for four assumed ratios of working capital to fixed investment.

The insert plot shows the effect on the Interest Rate of Return of changing assumptions concerning project life and method of depreciation. An improved rate of return is shown for the accelerated depreciation, which would not be recognized by the usual rate of return methods.

Present Value

The term *present value* is simply a numerical representation of the time value of money. If your money is gathering interest, the longer ago you invested it, the better. A dollar you received two years ago would have earned a dollar's worth of interest if earning 35%, as shown by the $2 present value (Figure 5). If you had to *spend* such a dollar two years ago your *loss* is increased just like the receipt, if it could have been at interest for those two years. The present value factor compounds dollars received before zero time from their face value to a larger value which they have at zero time either as receipts or expenditures, because of the time value of money.

Discounting or deducting interest by present-value factors is a numerical expression of the time value of money transactions in the future. The further off in the future a debt comes due that one has to pay, the better. A debt of $1 two years from now can be paid off with 50 cents available today, if one can put that money out at 35% interest. However, the same devaluation or discounting applies to money one will receive in the future. The longer the time before the money is due, the less it is worth today. A dollar due one in two years is worth only 50 cents today if outlets for one's present funds are earning 35% interest. At 35% interest, then, a dollar received after two years of life of a project will contribute only about 50 cents toward repayment of zero-time obligation, since 50 cents worth of interest will have been deducted from it over the two years.

Figure 5, which charts the present value of a dollar at various interest rates, will serve to emphasize the main point of this discussion. Consider the solid curve shown for a 35% interest rate, a rate used in the examples. A dollar to be received five years from now has a present value of slightly under 17 cents, after deducting interest (discounting) at 35%. That is, at 35% interest, a dollar received after five years of a project will contribute 17 cents toward repayment of zero-time obligation since 83 cents worth of interest has been deducted from it over the five years.

Another way of stating this relationship would be that 17 cents today, compounded with interest at 35% continuously for five years would yield a value of $1 five years from today. The present value of a dollar received or expended two years ago, and with interest applied at 35% compounded continuously, is just a little over $2.

Figure 5 also compares present values on a continuous and on an annual compounding basis. The broken line shows the

Interest Rate of Return

effect of an annual compounding period, the most common period. For a 35% interest rate compounded annually the interest rate, when compounding is performed on a continuous basis, is 42%. This is shown on Figure 6 at time −1. The broken line of 35% compounded annually shows a value of $1.35, while the solid line of 35% compounded continuously shows a value of $1.42. Even over a short five-year project, the difference between these two compounding methods is quite significant. The dollar, after deducting 35% interest, compounded annually, is worth 22 cents, while the dollar after deducting 35% interest, compounded continuously, is worth 17 cents, or only three quarters as much.

Application of continuous compounding to the receipts and expenditures of a business project lowers the interest rate of return compared with the rate which would be obtained if compounding were on an annual basis. Interest tables are available for both annual (*5, 17-21*) and continuous (*6*) (condensed in Table 6) compounding. The concept of continuous transactions throughout the year appears to be sound. Since at the higher interest rates and over longer time periods sizable differences are obtained, the continuous basis has been used.

Table 6.—Condensed Continuous Interest Tables (6)

(Factors for determining zero-time values for cash flows which occur at other than zero time.)

	1%	5%	10%	15%	20%	25%	30%	35%	40%	50%	60%	70%	80%	90%	100%
Compounding of cash flows which occur:															
A. *In an instant*															
½ year before	1.00	1.03	1.05	1.08	1.11	1.13	1.16	1.19	1.22	1.28	1.35	1.42	1.49	1.57	1.65
1 " "	1.01	1.05	1.11	1.16	1.22	1.28	1.35	1.42	1.49	1.64	1.82	2.01	2.23	2.46	2.72
1½ " "	1.02	1.08	1.16	1.25	1.35	1.46	1.57	1.69	1.82	2.12	2.46	2.86	3.32	3.86	4.48
2 " "	1.02	1.11	1.22	1.35	1.49	1.65	1.82	2.01	2.23	2.72	3.32	4.06	4.95	6.05	7.39
3 " "	1.03	1.16	1.35	1.57	1.82	2.12	2.46	2.86	3.32	4.48	6.05	8.17	11.02	14.88	20.09
B. *Uniformly until zero time*															
From ½ year before to 0 time	1.00	1.01	1.03	1.04	1.05	1.07	1.08	1.09	1.11	1.14	1.17	1.20	1.23	1.26	1.30
" 1 " " " " "	1.00	1.03	1.05	1.08	1.11	1.14	1.17	1.20	1.23	1.30	1.37	1.45	1.53	1.62	1.72
" 1½ " " " " "	1.01	1.04	1.08	1.12	1.17	1.21	1.26	1.32	1.37	1.49	1.62	1.77	1.93	2.12	2.32
" 2 " " " " "	1.01	1.05	1.11	1.17	1.23	1.30	1.37	1.45	1.53	1.72	1.93	2.18	2.47	2.81	3.19
" 3 " " " " "	1.02	1.08	1.17	1.26	1.37	1.49	1.62	1.77	1.93	2.32	2.81	3.41	4.18	5.14	6.36
Discounting of cash flows which occur:															
C. *In an instant*															
1 year later	.99	.95	.90	.86	.82	.78	.74	.70	.67	.61	.55	.50	.45	.41	.37
2 " "	.98	.90	.82	.74	.67	.61	.55	.50	.45	.37	.30	.25	.20	.17	.14
3 " "	.97	.86	.74	.64	.55	.47	.41	.35	.30	.22	.17	.12	.09	.07	.05
4 " "	.96	.82	.67	.55	.45	.37	.30	.25	.20	.14	.09	.06	.04	.03	.02
5 " "	.95	.78	.61	.47	.37	.29	.22	.17	.14	.08	.05	.03	.02	.01	.01
10 " "	.90	.61	.37	.22	.14	.08	.05	.03	.02	.01	—	—	—	—	—
15 " "	.86	.47	.22	.11	.05	.02	.01	.01	—	—	—	—	—	—	—
20 " "	.82	.37	.14	.05	.02	.01	—	—	—	—	—	—	—	—	—
25 " "	.78	.29	.08	.02	.01	—	—	—	—	—	—	—	—	—	—
D. *Uniformly over individual years*															
1st year	1.00	.98	.95	.93	.91	.88	.86	.84	.82	.79	.75	.72	.69	.66	.63
2nd "	.99	.93	.86	.80	.74	.69	.64	.59	.55	.48	.41	.36	.31	.27	.23
3rd "	.98	.88	.78	.69	.61	.54	.47	.42	.37	.29	.23	.18	.14	.11	.09
4th "	.97	.84	.70	.59	.50	.42	.35	.30	.25	.18	.12	.09	.06	.04	.03
5th "	.96	.80	.64	.51	.41	.33	.26	.21	.17	.11	.07	.04	.03	.02	.01
6th "	.95	.76	.58	.44	.33	.25	.19	.15	.11	.06	.04	.02	.01	.01	—
7th "	.94	.72	.52	.38	.27	.20	.14	.10	.07	.04	.02	.01	.01	—	—
8th "	.93	.69	.47	.32	.22	.15	.11	.07	.05	.02	.01	.01	—	—	—
9th "	.92	.65	.43	.28	.18	.12	.08	.05	.03	.01	.01	—	—	—	—
10th "	.91	.62	.39	.24	.15	.09	.06	.04	.02	.01	—	—	—	—	—
E. *Uniformly over 5-yr. periods*															
1st 5 years	.98	.88	.79	.70	.63	.57	.52	.47	.43	.37	.32	.28	.25	.22	.20
6th thru 10th year	.93	.69	.48	.33	.23	.16	.12	.08	.06	.03	.02	.01	—	—	—
11th " 15th "	.88	.54	.29	.16	.09	.05	.03	.01	.01	—	—	—	—	—	—
16th " 20th "	.84	.42	.18	.07	.03	.01	.01	—	—	—	—	—	—	—	—
21st " 25th "	.80	.33	.11	.04	.01	—	—	—	—	—	—	—	—	—	—
F. *Declining to nothing at constant rate*															
1st 5 yr.	.98	.92	.85	.79	.74	.69	.64	.60	.57	.51	.46	.41	.38	.35	.32
" 10 "	.97	.85	.74	.64	.57	.51	.46	.41	.38	.32	.28	.24	.22	.20	.18
" 15 "	.95	.79	.64	.54	.46	.39	.35	.31	.28	.23	.20	.17	.15	.14	.12
" 20 "	.94	.74	.57	.46	.38	.32	.28	.24	.22	.18	.15	.13	.12	.10	.10
" 25 "	.92	.69	.51	.39	.32	.27	.23	.20	.18	.15	.12	.11	.10	.08	.08

Nominal and Effective Interest Rates

Since *nominal* Interest Rates of Return are used for solution of sample cases and as column headings in Table 6, the terms *nominal* and *effective* as applied to interest rates may be considered briefly. The *effective* rate is the rate at which a sum of money earns interest each year, regardless of compounding period. The *nominal* rate is the rate at which a sum of money earns interest over a particular compounding period. The nominal rate equals the effective rate only when the compounding period is one year. Although nominal rates are usually expressed on an annual basis, these rates are inaccurate unless qualified by their compounding period, i.e., 20% compounded quarterly, or 20% compounded continuously. $1,000 at 20% compounded annually would accrue interest of $200 by the year end; compounded semi-annually, $210; and compounded continuously, $220. The nominal rate in all three cases is 20% with compounding period specified; the effective rate is 20, 21, and 22%, respectively.

Continuous Interest Table

The last and perhaps most useful exhibit, Table 6, is a condensed continuous interest table abstracted from J. C. Gregory's "Interest Tables for Determining Rate of Return" (*6*). The table consists of six groups of present-value factors for transactions occurring in a single sum or uniformly over specified periods of time and also for occurrences before and after the selected zero point.

Part A provides factors for compounding single-sum transactions occurring in an instant before zero time, such as the expenditure for land noted in the sample cases.

Part B provides factors for compounding cash receipts or expenditures which take place steadily over a period of time before the zero point, such as the outlay for construction of the plant used in the sample cases.

Part C provides factors for discounting transactions which occur in an instant after the zero point, such as the recovery of working capital, land, and scrap value in the sample cases.

Part D provides factors for discounting cash receipts or expenditures which take place steadily over individual years after the zero point, such as the cash receipts for the five individual years in the sample cases.

Part E provides factors for transactions similar to those in Part D but taking place steadily over five-year periods instead of individual years. This reduces calculations required when receipts or expenditures follow such a pattern.

Part F. Under sum-of-the-years-digits depreciation, cash from depreciation allowances is returned from the project in amounts which diminish continuously on a straight-line basis from a maximum at the start to zero at the end of the life of the depreciable item. This table provides factors for discounting such transactions over various time periods.

The original tables (*6*) covered 1% increments and were taken to four decimal places. The accuracy of estimates available for most project forecasts can, it is felt, be maintained by using 5% increments and the two-decimal-place factors shown in Table 6. These simplifications also permit slide-rule solutions.

Extension Methods for Continuous Interest Tables

A number of extensions may be made to Table 6 for interest rates and time periods not covered. Some of these techniques can be used only on interest tables based, like Table 6, on an infinitesimal compounding period.

1. INSTANTANEOUS FACTORS FOR EXTENSION TO ADDITIONAL YEARS

The factors for instantaneous transactions (Parts A and C) can be multiplied together to obtain factors for years not shown. In Part C, the factor for 11 years later is the ten-year factor times the one-year factor.

Example at 35%: (.70) (.03) = .02

Parts B, D, E, and F, for transactions taking place over periods of time, are extended to other years by applying the appropriate instantaneous factor to postpone the period over which the transaction occurs. The 11th year factor in Part D may be found as (Part C, 1-year factor) × (Part D, 10-year factor) or as (Part C, 10-year factor) × (Part D, 1-year factor).

Examples at 35%: (.70) (.04) = .03
(.03) (.84) = .03

2. ADDITIONAL EXTENSIONS FOR PARTS A, B, C, AND F.

Because of the instantaneous compounding period, a relationship exists which permits determination of factors for rates and times not shown in these tables. Perhaps the easiest way to describe this characteristic is to point out the equivalence of certain factors appearing in Table 6. In Part C, the factor 0.37, for one year later at 100%, is the same as the factor for two years later at 50%. The same factor, 0.37, also appears at four years at 25%, five years at 20%, 10 years at 10%, 20 years at 5%. When compounded continuously the factor depends upon the product of the interest rate and the time involved. In each of the cases cited above, since the product of the rate and the time is 100, the factor is the same. With the application of this principle to, say, the 40% rate, the factor for 2½ years at 40% is also 0.37. The factors shown should allow both interpolation and extrapolation with some ease.

3. ADDITIONAL EXTENSIONS FOR PARTS D AND E

Since the periods shown for transactions do not generally extend to zero time in Parts D and E, the flexibility described above does not apply. However, another convenient relationship between Tables D and E can be used for extension. The factor for 1% over the first five years (Part E), 0.98, is the same as the factor for 5% over the first year (Part D), and this relationship also holds for later time periods in the order shown in the tables. The 2% factor over the sixth through 10th year can be found from these tables as 0.86, the 10% factor over the second year.

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CAPITALIZED COST

as a method for comparison of alternatives

Capitalized cost offers a simple and exact method of comparing costs of alternatives on a common-denominator basis. It allows for interest and can be used for a single article or expense or for a whole plant. Differences in first cost, service life, operating expense, deferred costs, obsolescence, and salvage value are accounted for, and there is no limit to the items which can be considered. The calculations are readily made with the help of only a few tabulated factors. Capitalized cost is the present value of all costs for an indefinite time, but comparisons are correct for limited periods.

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In chemical engineering problems there is seldom only one way to accomplish an end. Usually there are several alternatives, and the final choice should be made in terms of the most economical means, with interest (the time value of money) included. The importance of cost comparisons is readily shown by their increasing occurrence in professional engineering examinations; yet many chemical engineers are not familiar with a method for making the calculations. This article presents a rigorously exact and intelligible method which is readily applied without limitations.

An engineering cost embraces two time factors:

1. Year when incurred, that is, now or later.
2. Duration.

Costs of alternatives can be compared directly only when both time factors have been reduced to some common basis. For example, a $10,000 repair expense now that will last two years cannot be compared directly with a $30,000 cost next year for a new article that will last 7 years. The expenses differ in the year in which they occur and the period over which they extend.

Definition

Capitalized cost is a concept which reduces these two time factors to a common basis. First, all costs are reduced to their present value, which corrects for the difference in time at which costs may occur. Second, all costs are reduced to the equivalent cost on a "forever" basis, which corrects for the difference in duration of costs. This method does not imply that an article or a cost is continued forever. *Forever* is used merely as a common denominator for all service lives.

The term *capitalized cost* represents the present cost on a perpetual basis, for the purpose of calculation. Capitalized cost is useful principally in comparing alternatives. As it allows for interest for the use of capital, the alternative which has the lowest capitalized cost is the most economical.

Initial Cost

Suppose an article costs C and lasts m years and money is worth i per year expressed as a decimal.

The first article will cost C and its present value will be C. The next article will likewise cost C, but the expense will be incurred m years hence. The present value is $C/(1+i)^m$. Similarly the present value of the next replacement is $C/(1+i)^{2m}$, etc. The capitalized cost K is

$$K = C\sum_{a=0}^{a=\infty}\frac{1}{(1+i)^{am}}$$

The Σ part is an infinite geometric series, and the equation reduces to

$$K = CF_m = C(1+G_m) \qquad (1)$$

where

$$F_m = \frac{(1+i)^m}{(1+i)^m-1}$$

$$G_m = \frac{1}{(1+i)^m-1}$$

Values of G_m for various rates i have been calculated and are given in Table 1. A table of F_m factors is not included, as F_m is obtained simply by adding 1 to the corresponding G_m factor.

Equation (1) is the basis for solving many simple problems.

Example 1 A tank costs $10,000 and lasts 5 years. If money is worth 8% per year, how much can be spent for painting the tank when new so as to get 6 years' life?

This problem merely compares the cost for a 6-year tank to that for a 5-year tank. By Equation (1) the capitalized cost for a new tank without painting is

$$K = 10{,}000F_5 = (10{,}000)(3.131) = \$31{,}310$$

For the same capitalized cost for a 6-year life

$$31{,}310 = CF_6 = C(2.704)$$
$$C = \$11{,}579$$
$$11{,}579 - 10{,}000 = \$1{,}579$$

That is, $11,579 could be spent for a 6-year tank, or $1,579 over the cost of a 5-year tank.

Example 2 A tank costs $10,000 and lasts 5 years. If money is worth 8% per year, how much can be spent now to patch up an old worn-out tank to give another year's service?

By Equation (1) the capitalized cost for a new tank is

$$K = 10{,}000F_5 = (10{,}000)(3.131) = \$31{,}310$$

The capitalized cost for the repair job for a 1-year life must not exceed this.

$$31{,}310 = CF_1 = C(13.50)$$
$$C = \$2{,}319$$

That is, up to $2,319 can be spent for

patching the old tank to get another year's service.

The difference between Examples 1 and 2 should be noted. From Example 1, when the new tank is purchased, \$1,579 extra can be spent to gain 1-year's life between the fifth and sixth years. From Example 2, \$2,319 can be spent to gain an extra year's service when the tank is worn out. These amounts are equivalent, for \$1,579 at 8% compound interest for 5 years amounts to \$2,319.

$$(1{,}579)(1.08)^5 = \$2{,}319$$

Uniform Yearly Expense

Let M be a net uniform annual expense. Then M can be regarded as equivalent to an article costing M and lasting one year. The capitalized cost by Equation (1) is

$$K = MF_1 = M(1 + G_1) \qquad (2)$$

Here M must be constant from year to year.

Example 3 A tank costs \$10,000 and lasts 5 years. If money is worth 8% per year, how much can be spent uniformly each year for painting so as to get 6-years' life?

By Equation (1) the capitalized cost for a new tank is

$$K = 10{,}000F_5 = (10{,}000)(3.131) = \$31{,}310$$

For the tank maintained by painting there is the capitalized cost of the \$10,000 initial cost, now extending for 6 years, and the capitalized cost of the yearly painting expense M. They are calculated from Equations (1) and (2) respectively, and their sum must not exceed \$31,310.

$$31{,}310 = 10{,}000F_6 + MF_1$$
$$31{,}310 = (10{,}000)(2.704) + (13.5)$$
$$M = \$316$$

\$316 can be spent per year over the 6-year period.

The result obtained in Example 3 is equivalent to the results obtained in Examples 1 and 2. From Example 1 \$1,579 extra is a justified expense for the tank when new for an extra year's service. At the end of 6 years \$1,579 will amount to \$2,506.

$$(1{,}579)(1.08)^6 = \$2{,}506$$

Also \$316 at the beginning of each year will amount to \$2,506 at the end of 6 years.

$$316[(1.08)^6 + (1.08)^5 + (1.08)^4 + (1.08)^3 + (1.08)^2 + (1.08)^1] = \$2{,}506$$

Salvage Value

Although Equations (1) and (2) together are adequate for solving many problems in cost comparisons, there is no limit to the types of cost which can be considered by capitalized cost. Salvage value must be included frequently. Suppose an article has a salvage value L at the end of m years, the life of the article. The present value of L is $L/(1+i)^m$ and the capitalized cost by Equation (1) is

$$K = -\frac{L}{(1+i)^m}\,\frac{(1+i)^m}{(1+i)^m - 1}$$

$$K = -LG_m \qquad (3)$$

The negative sign denotes that a salvage value is a negative cost.

Varying Yearly Expense

Equation (2) is the capitalized cost of a uniform yearly expense M but is not suitable if the yearly expense varies. In practice it is necessary sometimes to consider varying yearly expenses.

Suppose an article lasting m years incurs an expense B_j during the jth year. The present value of this expense brought forward $(j-1)$ years, is $B_j/(1+i)^{j-1}$. By Equation (1) the capitalized cost is

$$K = \frac{B_j}{I_{(j-1)}} F_m = \frac{B_j}{I_{(j-1)}}(1 + G_m) \qquad (4)$$

where

$$I_{(j-1)} = (1+i)^{j-1}$$

Values of the compound interest factor I_m are given in Table 2.

Equation (4) can be used for any year or term by term for all the years. A more general form is

$$K = F_m \sum_{j=1}^{j=m} \frac{B_j}{I_{(j-1)}} = (1 + G_m) \sum_{j=1}^{j=m} \frac{B_j}{I_{(j-1)}} \qquad (5)$$

Equation (5) will accommodate varying yearly expenses however irregular they may be.

Example 4 A tank costs \$10,000 and lasts 5 years. An old tank can be patched up now for \$1,500 to give 1 year more life, then for \$2,000 to give another year's life, then for \$2,500 to give another year's life, etc. If money is worth 8% per year,

Table 1.—Value of $G_m = \dfrac{1}{(1+i)^m - 1}$

To Be Used Also for F_m Where $F_m = 1 + G_m$

m	2%	4%	6%	8%	10%	12%	14%	16%	18%	20%	25%	30%	35%	40%	50%
1	50.00	25.00	16.67	12.50	10.00	8.333	7.143	6.250	5.556	5.000	4.000	0.1041	0.07197	0.05086	0.02671
2	24.75	12.25	8.091	6.010	4.762	3.931	3.338	2.894	2.548	2.273	1.778	3.333	2.857	2.500	2.000
3	16.34	8.006	5.235	3.851	3.021	2.470	2.077	1.783	1.555	1.374	1.049	1.449	1.216	1.042	0.8000
4	12.14	5.887	3.810	2.774	2.155	1.744	1.451	1.234	1.065	0.9314	0.6937	0.8354	0.6847	0.5734	0.4211
5	9.608	4.616	2.957	2.131	1.638	1.312	1.081	0.9088	0.7765	0.6719	0.4874	0.5388	0.4308	0.3519	0.2462
6	7.924	3.769	2.389	1.704	1.296	1.027	0.8368	0.6962	0.5884	0.5035	0.3553	0.3686	0.2870	0.2284	0.1517
7	6.725	3.165	1.986	1.401	1.054	0.8260	0.6656	0.5476	0.4576	0.3871	0.2654	0.2613	0.1979	0.1532	0.09624
8	5.825	2.713	1.684	1.175	0.8744	0.6775	0.5379	0.4389	0.3625	0.3030	0.2016	0.1896	0.1394	0.1048	0.06217
9	5.126	2.362	1.450	1.001	0.7364	0.5640	0.4441	0.3568	0.2911	0.2404	0.1550	0.1397	0.09968	0.07268	0.04060
10	4.566	2.082	1.264	0.8629	0.6275	0.4749	0.3694	0.2931	0.2362	0.1926	0.1203	0.07821	0.05234	0.03581	0.01765
11	4.109	1.854	1.113	0.7510	0.5396	0.4035	0.3100	0.2429	0.1932	0.1555					
12	3.728	1.664	0.9879	0.6587	0.4676	0.3453	0.2619	0.2026	0.1590	0.1263					
13	3.406	1.504	0.8827	0.5815	0.4078	0.2973	0.2226	0.1699	0.1316	0.1031					
14	3.130	1.367	0.7931	0.5162	0.3575	0.2573	0.1901	0.1431	0.1093	0.08446					
15	2.891	1.249	0.7160	0.4604	0.3147	0.2235	0.1629	0.1210	0.09070	0.06925					
20	2.088	0.8396	0.4531	0.2732	0.1746	0.1157	0.07847	0.05417	0.03789	0.02678					
25	1.561	0.6003	0.3038	0.1710	0.1017	0.06250	0.03927	0.02508	0.01622	0.01059					
30	1.232	0.4457	0.2108	0.1103	0.06079	0.03453	0.02002	0.01162	0.007024	0.004231					
35	1.000	0.3394	0.1496	0.07254	0.03690	0.01931	0.01030	0.005577	0.003058	0.001696					
40	0.8278	0.2631	0.1077	0.04825	0.02259	0.01086	0.005323	0.002647	0.001334	0.0006808					
45	0.6955	0.2066	0.07834	0.03234	0.01391	0.006135	0.002757	0.001259	0,0005829	0.0002735					
50	0.5912	0.1638	0.05741	0.02179	0.008592	0.003472	0.001430	0.0005989	0.0002547	0.0001099					

Table 2.—Value of $I_m = (1+i)^m$

m	2%	4%	6%	8%	10%	12%	14%	16%	18%	20%	25%	30%	35%	40%	50%
1	1.0200	1.0400	1.0600	1.0800	1.1000	1.1200	1.1400	1.1600	1.1800	1.2000	1.2500	1.3000	1.3500	1.4000	1.5000
2	1.0404	1.0816	1.1236	1.1664	1.2100	1.2544	1.2996	1.3456	1.3924	1.4400	1.5625	1.6900	1.8225	1.9600	2.2500
3	1.0612	1.1249	1.1910	1.2597	1.3310	1.4049	1.4815	1.5609	1.6430	1.7280	1.9531	2.1970	2.4604	2.7440	3.3750
4	1.0824	1.1699	1.2625	1.3605	1.4641	1.5735	1.6890	1.8106	1.9388	2.0736	2.4414	2.8561	3.3215	3.8416	5.0625
5	1.1041	1.2167	1.3382	1.4693	1.6105	1.7623	1.9254	2.1003	2.2878	2.4883	3.0518	3.7129	4.4840	5.3782	7.5938
6	1.1262	1.2653	1.4185	1.5869	1.7716	1.9738	2.1950	2.4364	2.6996	2.9860	3.8147	4.8268	6.0534	7.5295	11.391
7	1.1487	1.3159	1.5036	1.7138	1.9487	2.2107	2.5023	2.8262	3.1855	3.5832	4.7684	6.2749	8.1722	10.541	17.086
8	1.1717	1.3686	1.5938	1.8509	2.1436	2.4760	2.8592	3.2784	3.7589	4.2998	5.9605	8.1573	11.032	14.758	25.629
9	1.1951	1.4233	1.6895	1.9990	2.3579	2.7731	3.2520	3.8030	4.4355	5.1598	7.4506	10.605	14.894	20.661	38.443
10	1.2190	1.4802	1.7908	2.1589	2.5937	3.1058	3.7072	4.4114	5.2338	6.1917	9.3132	13.786	20.107	28.925	57.665
11	1.2434	1.5395	1.8983	2.3316	2.8531	3.4785	4.2262	5.1173	6.1759	7.4301					
12	1.2682	1.6010	2.0122	2.5182	3.1384	3.8960	4.8179	5.9360	7.2876	8.9161					
13	1.2936	1.6651	2.1329	2.7196	3.4523	4.3635	5.4924	6.8858	8.5994	10.699					
14	1.3195	1.7317	2.2609	2.9372	3.7975	4.8871	6.2614	7.9875	10.147	12.839					
15	1.3459	1.8009	2.3966	3.1722	4.1772	5.4736	7.1380	9.2655	11.974	15.407					
20	1.4859	2.1911	3.2071	4.6610	6.7275	9.6463	13.744	19.461	27.393	38.338					
25	1.6406	2.6658	4.2919	6.8485	10.835	17.000	26.462	40.874	62.669	95.396					
30	1.8114	3.2434	5.7435	10.063	17.449	29.960	50.950	87.044	143.37	237.38					
35	1.9999	3.9461	7.6861	14.785	28.102	52.800	98.101	180.31	328.00	590.67					
40	2.2080	4.8010	10.286	21.725	45.259	93.051	188.88	378.72	750.38	1,469.8					
45	2.4379	3.8412	13.765	31.920	72.891	163.99	363.68	795.44	1,716.7	3,657.2					
50	2.6916	7.1067	18.420	46.902	117.39	289.00	700.24	1,670.7	3,927.3	9,100.4					

how long should the old tank be patched up?

By Equation (1) the capitalized cost for a new tank is

$$K = 10{,}000F_5 = (10{,}000)(3.131) = \$31{,}310$$

If the old tank is patched for 2 years, then 7 years' expenses will be \$1,500 and \$2,000 during the first and second years respectively, for patching the old tank and \$10,000 during the third year for a new tank. By use of Equation (5)

$$\frac{B_j}{I_{(j-1)}} = \frac{1{,}500}{1} = 1{,}500$$

$$= \frac{2{,}000}{1.08} = 1{,}852$$

$$= \frac{10{,}000}{1.1664} = 8{,}573$$

$$\Sigma = 11{,}925$$

$$K = F_7\Sigma = (2.401)(11{,}925) = \$28{,}630$$

From similar calculations the following tabulation can be made.

No. years tank is patched	Capitalized Cost, \$
0	31,310
1	29,090
2	28,630
3	29,220
4	30,470
5	32,150

The tank should be patched for 2 years, to obtain the minimum capitalized cost, \$28,630. It will be noted that it is cheaper to patch for 3 or even 4 years compared with buying a new tank every 5 years, though not so cheap as patching for just 2 years.

Periodic Overhaul

Equation (5) can be used for any kind of deferred costs, but if the deferred costs have some degree of regularity it sometimes is advantageous to reduce Equation (5) to a simpler form. One such case is periodic overhauls.

Suppose an article lasts m years and receives an overhaul costing H every p years, starting after p years. The capitalized cost of these overhauls is

$$K = HG_p \tag{6}$$

where G_p is obtained from Table 1.

Mathematically the conditions for Equation (6) are equivalent to those which led to Equation (3) and so Equation (6) is obvious from Equation (3).

In practice Equation (6) may be subject to a variation. The time when the last overhaul is due usually coincides with the time when the article is completely worn out; hence this overhaul will be omitted and recovered as a salvage value. Thus a more realistic equation for the capitalized cost of the overhauls is

$$K = H(G_p - G_m) \tag{7}$$

in which it is recognized that one overhaul will be omitted.

Equation (7) is adequate for all practical problems but is rigorously exact only if m is an integral multiple of p. Let u be the number of years from the occurrence of the last overhaul performed to the expiration of the life of the article, m years. The capitalized cost of the overhauls is

$$K = H\left(G_p - \frac{G_p}{G_u}G_m\right) \tag{8}$$

Equation (8) has some generality. It remains valid even if $u > p$ and reduces to Equation (7) when $u = p$.

An Extensive Example

Example 5 demonstrates how various types of costs are treated in one problem.

Example 5 A heat exchanger uses steel tubes which cost \$10,000 and last 4 years with \$2,000 salvage value. Cost for cleaning the inside of the tubes is \$3,000 per year. Every 2 years the outside of the tubes must be cleaned at a cost of \$4,000. During the fourth year there is an extra maintenance expense of \$1,500. It is proposed to substitute alloyed tubes costing \$95,000 which last 10 years with \$20,000 salvage value. Maintenance of the alloyed tubes is \$1,000 per year and the saving from increased production is \$6,000 per year or a net of −\$5,000 per year. If money is worth 8% per year, does it pay to install the alloyed tubes?

Capitalized cost of the steel tubes is

$$CF_4 = (10{,}000)(3.774) = 37{,}740$$

$$-LG_4 = -(2{,}000)(2.774) = -5{,}548$$

$$MF_1 = (3{,}000)(13.5) = 40{,}500$$

$$H(G_2 - G_4) = (4{,}000)(6.010\text{-}2.774) = 12{,}944$$

$$\frac{B_4}{I_4}F_4 = \frac{1{,}500}{1.2597}\,3.774 = 4{,}494$$

$$\text{Total} = \$90{,}130$$

Capitalized cost of the alloyed tubes is

$$CF_{10} = (95{,}000)(1.8629) = 176{,}976$$

$$-LG_{10} = -(20{,}000)(0.8629) = -17{,}258$$

$$MF_1 = -(5{,}000)(13.5) = -67{,}500$$

$$\text{Total} = \$92{,}218$$

Capitalized cost of the steel tubes is \$90,130 against \$92,218 for the alloyed tubes; hence it will not pay to substitute the latter.

Pay-Out Time

Pay-out time can be calculated on the basis of capitalized cost.

Example 6 Chemical analysis at a cost of $9,000 per year is used for quality control on a product. An automatic controller costing $40,000 has just been introduced. Cost of operating the controller with supervision is $6,000 per year, but it will save $10,000 per year in reduction of spoiled product, thus giving a net expense of −$4,000 per year. If money is worth 8% per year, how long will it take for the automatic controller to pay out?

Capitalized cost for control by chemical analysis is

$$MF_1 = (9{,}000)(13.5) = \$121{,}500$$

Capitalized cost for the automatic controller on the basis of 3 years' service is

$$\begin{aligned} CF_3 &= (40{,}000)(4.851) = 194{,}040 \\ MF_1 &= -(4{,}000)(13.5) = -54{,}000 \\ &\text{Total} = \$140{,}040 \end{aligned}$$

Capitalized cost for the automatic controller on the basis of 4 years' service is

$$\begin{aligned} CF_4 &= (40{,}000)(3.774) = 150{,}960 \\ MF_1 &= -(4{,}000)(13.5) = -54{,}000 \\ &\text{Total} = \$96{,}960 \end{aligned}$$

The automatic controller will not pay out in 3 years (capitalized cost of $140,040 against $121,500) but will more than pay out in 4 years ($96,960 against $121,500). Pay-out time is about 3.4 years.

Possibility of Obsolescence

In some cases the threat of obsolescence must be considered. A more expensive, long-lasting article, which otherwise may be the more economical of two considered, may be a poor choice because of the danger that it will have to be abandoned before its full life can be realized.

Such problems can be treated on a probability basis. It is necessary only to consider all the probabilities and to assign them in such a manner that the total is unity. Example 7 demonstrates the method.

Example 7 A cast iron pot costs $15,000 and will last 5 years. A clad pot costs $20,000 and will last 20 years. It is estimated that the process in which they would be used cannot be continued more than 10 years and the odds are 3 to 2 that it will be continued for 5 years only. If money is worth 8% per year, which pot should be installed?

Capitalized cost of the cast iron pot is

$$K = 15{,}000F_5 = (15{,}000)(3.131) = \$46{,}965$$

Capitalized costs of the clad pot on the basis of 5- and 10-years' service are

$$K = 20{,}000F_5 = (20{,}000)(3.131) = 62{,}620$$

$$K = 20{,}000F_{10} = (20{,}000)(1.8629) = 37{,}258$$

The probability that the pot will be used 5 years is 0.6 and 10 years 0.4. If each of the foregoing capitalized costs is multiplied by the probability of its occurrence and the two are added together, the figure obtained is the probable capitalized cost:

$$K_{probable} = (0.6)(62{,}620) + (0.4)(37{,}258)$$

$$K_{probable} = \$52{,}475$$

On a sure 10-year basis the clad pot would be the choice (capitalized cost of $37,258 against $46,965). However, the threat of obsolescence of the process in 5 years gives the clad pot a probable capitalized cost of $52,475; hence the cast iron pot is the choice.

Equivalent Uniform Yearly Cost

In presenting conclusions to others one sometimes finds it more convenient to express the results as a yearly cost. As capitalized cost represents cost on a perpetual basis, multiplication by the interest rate gives a yearly cost. Let

$$k = iK \qquad (9)$$

where k is the equivalent uniform end-of-year yearly cost. The significance of this method is easily shown by a numerical example.

Example 8 An article costs $10,000 and lasts 3 years. If money is worth 8% per year, what is the equivalent uniform yearly cost? Show that it will exactly repay for the first cost.

The capitalized cost by Equation (1) is

$$K = 10{,}000F_3 = (10{,}000)(4.851) = 48{,}510$$

The equivalent uniform yearly cost by Equation (9) is

$$k = iK = (0.08)(48{,}510) = \$3{,}881$$

Thus $3,881 is the equivalent uniform (end-of-year) yearly cost.

The first payment of $3,881 at the end of the first year will draw interest for 2 years, the next payment for 1 year, and the third payment for 0 years. At the end of 3 years the payments will amount to $12,597.

$$\begin{aligned} (3{,}881)(1.08)^2 &= 4{,}525 \\ (3{,}881)(1.08)^1 &= 4{,}191 \\ (3{,}881)(1.08)^0 &= 3{,}881 \\ \text{Total} &= \$12{,}597 \end{aligned}$$

The original $10,000 is also worth $12,597 at the end of 3 years.

$$(10{,}000)(1.08)^3 = \$12{,}597$$

Example 8 should make it evident that, although capitalized cost is based on all costs for an indefinite time, comparisons made from it for limited times are correct. In Example 8 the article has been paid for by the equivalent uniform yearly cost, which is derived directly from the capitalized cost, and at the end of 3 years it does not matter whether the article is replaced in kind, replaced by something else, or even not replaced at all.

A yearly expense does not have quite the same equivalent uniform yearly cost. Suppose a process has a yearly expense of $100,000 with money worth 8% per year, then the capitalized cost by Equation (2) is

$$K = MF_1 = (100{,}000)(13.5) = 1{,}350{,}000$$

and the equivalent uniform yearly cost by Equation (9) is

$$k = iK = (0.08)(1{,}350{,}000) = \$108{,}000$$

The equivalent uniform yearly cost is an end-of-year cost and the $108,000 includes $8,000 for interest for the use of $100,000 for 1 year.

Effect of Interest Rate

Capitalized cost is dependent upon the interest rate used in the calculation. A high interest rate tends to favor the article with the shorter life, a low interest rate that with the longer life. A conclusion obtained at one interest rate may be reversed at another. This aspect is not peculiar to capitalized cost but is common to all methods where interest is considered. It emphasizes, however, that the interest rate must be chosen with some care.

Notation

B_j = expense during the jth year, dollars
C = initial cost, dollars
F_m = factor $\dfrac{(1+i)^m}{(1+i)^m - 1} = (1 + G_m)$
G_m = factor $\dfrac{1}{(1+i)^m - 1}$
H = cost of a periodic overhaul, dollars
i = interest rate, decimal per year
I_m = compound-interest factor = $(1+i)^m$
j = jth year
k = equivalent uniform yearly cost, dollars per year
K = capitalized cost, dollars
L = salvage value, dollars
m = service life, years
M = net uniform annual expense, dollars per year
p = period between overhauls, years
u = period from last overhaul to end of useful life, years

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The production of power by the fission of heavy elements gives rise to a new type of industrial waste—the radioisotope. This waste is unique in that it continuously generates heat by the decay of the fission products. This rate of heat generation is sufficient to create problems in the containment of these wastes and places practical limitations on the methods which may be employed. Up to the present time the only method demonstrated on a large scale is the semipermanent storage of these wastes in buried tanks. Other disposal methods are in various stages of development but all suffer from severe limitations imposed by the self-heating characteristics of the wastes. The removal of cesium and strontium from the waste decreases markedly the time that the self-heating characteristic remains as a practical operating problem and paves the way for the eventual storage of the residual wastes by ion exchange in the soil in some arid, isolated location.

HEAT PROBLEMS in the disposal of HIGH LEVEL RADIOACTIVE WASTES

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The fission of an atom such as uranium-235 is actually a cleavage of the atom forming two fission fragments (or fission products), along with a few extra neutrons. The extra neutrons are consumed in the chain reaction within the reactor and are of no interest here. The fission products formed are elements having atomic weights between 0.3 and 0.7 of the atomic weight of the element fissioned, with the majority of the fission products having a mass 40 to 60% that of the parent atom. This phenomenon is depicted on Figure 1 which shows the relative abundance of the various fission products of different atomic weights. Atoms of atomic weight 85 to 105 and 130 to 150 are most frequently formed, with an exactly even split of the atom being relatively rare. The relative abundance of the fission products changes only slightly if the fissionable material is changed from uranium-235 to plutonium-239. A comparable slight shift would be noticed in the opposite direction if uranium-233 were substituted.

Whereas many fission products formed in this manner are stable or decay rapidly to a stable element, some of these nuclides decay with half-lives varying up to 37 years; for example, the decay rate of cesium-137 is such that its rate of beta and gamma emissions is reduced by a factor of 2 every 37 years. Figure 2 shows heat released as a function of time after a fuel element has been discharged from a nuclear reactor, on the assumption that one ton of uranium containing 1.2% by weight of uranium-235 was irradiated at a power level of 5 mw./ton(megawatts per ton) to a total irradiation of 2,500 mwd./ton (megawatt days per ton). The over-all rate of heat evolution is steadily declining although the rate of decrease slows down with time. This is true because most of the heat is contributed at first by the short-lived fission products, such as zirconium, niobium, ruthenium-103, etc. Later, the heat is produced primarily by cerium and its praseodymium daughter, ruthenium-106 and its rhodium daughter, strontium, and cesium, with the contribution of each diminishing with time in that order.

While this curve assumes specific conditions of fuel-element composition and irradiation, a curve for any other practicable condition of power production would be similar in shape, and the heat generation problems in disposing of radioactive wastes would be quite comparable.

Heat Generation Under Operating Conditions

The rate of heat generation in storage tanks under operating conditions will be somewhat different from the simple case depicted here. Figure 3 depicts the rate of heat generation in a tank receiving radioactive wastes from a separations plant processing irradiated fuel elements. Again, the assumption is uranium containing 1.2% uranium-235 irradiated at a level of 5 mw./t. to a total of 2,500 mwd./ton. As a further simplification, the assumption is made that the separations plant is processing 1 ton of irradiated uranium/day. To convert the numbers quoted here to any other operating rate, it is necessary only to multiply the observed heat generation rate by the average processing rate in tons per day. A further assumption is made that the fuel elements are cooled 90 days before the chemical waste from their processing is added to the storage tank. As shown in this figure, the operation of a waste storage tank is divided into two periods: the first, or filling period, is the time during which the tank is being filled; the second, or cooling period, occurs after the filling operation terminates. During the filling period, the major portion of the heat generated is by the short-lived fission products. The total rate of heat generation in the tank rises rapidly at first, the rate of increase being roughly proportional to the quantity of short-lived fission products which are added to the tank. In a few months, however, it is noted that the short-lived fission products which were added to the tank in the first increments have decayed to the point where the cumulative rate of heat increase is slowed down (that is, the short half-lived fission products are reaching a saturation point where the rate of decay equals the rate of addition to the tank). Further operation of the tank results in an ever-slowing increase in the rate of heat generation, this value becoming effectively asymptotic to a value which is proportional to the rate

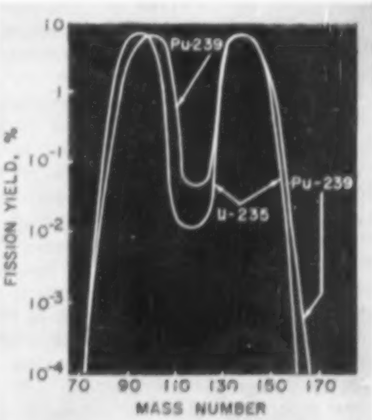


Fig. 1. Mass distribution of fission products. U^{235} and Pu^{239} fission yield curves.

of power production in the nuclear reactor and the rate at which the fuel is being replaced. In this particular case, with the assumption of the 1 ton/day operating rate, the effective asymptotic heat generation rate is about 2.5×10^6 B.t.u./hr. and corresponds to a nuclear reactor producing 2½-million kw. heat energy on a continuous basis.

The cooling period curves represent the rate of heat generation which would be observed if the tank were filled for the indicated periods of time and then permitted to decay. A tank filled for a short period of time contains a relatively large fraction of the short-lived fission products and the rate of heat generation falls rapidly toward a low value as the heat generated by the short-lived fission products diminishes to a negligible amount. A tank filled for a much longer time, however, contains a higher fraction of the long-lived fission products and the rate of heat generation falls off much more slowly.

Storage of Radioactive Wastes in Tanks

Up to now, most of the high level radioactive wastes produced have been stored as an aqueous solution or slurry in underground tanks. These tanks are primarily vessels constructed of mild steel and reinforced concrete, although in a few cases the use of stainless steel has been dictated by special conditions. Vessels have been of varied sizes, ranging from 30,000 to one-million gallon capacities. The heat generated within these tanks heats the tank and its contents and then is lost to the surrounding soil. In general, a buried vessel of about 500,000-gal. capacity can dissipate about 200,000 B.t.u./hr. to the soil while maintaining a temperature just below the boiling point of an aqueous solution. This value was observed for a vessel buried in nearly dry sand and would, of course, vary with the nature of the containing soil. As a rough rule of thumb, the rate of heat loss from a vessel of a different size may be estimated on the assumption that the rate of heat loss is proportional to the surface area of the tank.

When the rate of heat generation within a tank exceeds the rate of heat dissipation, the contents of the tank evaporate, and self-concentration may be effected by condensing the vapors and disposing of the condensate as a slightly radioactive solution. Figure 4 presents in schematic form the equipment layout utilized at Hanford to effect self-concentration. The buried storage tank is of reinforced concrete with a mild steel liner. The vapors pass through a deentrainment device pictured here as a cyclone separator and are condensed in a buried condenser. The condensate is routed to a crib from which it percolates into the soil. The whole system is vented to the atmosphere through a filter and stack. Additional tanks are manifolded into the vapor system such that a single condenser and vent service the entire farm.

SUDDEN BOILING EFFECT

When the depth of the solution in the tanks is small (say, a few feet), the solution boils gently and the self-concentration proceeds uniformly. If, however, the depth of the solution is larger (say, 20 ft. or more), the boiling mass periodically produces an accelerated evaporation rate of 50 to 100 times the average rate of evaporation, subsiding to normal rates in 20 to 30 min. This "bumping" action is believed to result from the sudden release of heat which has been stored as sensible heat of the liquid deep in the tank, where the boiling point of the solution is increased by the hydrostatic head upon it. The rapid release may be triggered by any phenomenon which would start a local current of solution upward, such as the insertion of a foreign object into the tank, the shifting of a sludge layer by vaporization within it, or by other mechanical movements. This upward movement reduces the pressure on the liquid and permits it to break into a boil. The vapor thus formed further reduces the pressure at the bottom of this local column of rising liquid and further accelerates the boiling action. The rapid boiling then continues until the reservoir of excess sensible heat has been dissipated sufficiently for the local upward current of liquid to subside. This theory seems to explain the bumping phenomena observed, although data sufficient to establish the controlling factors and relationships are still being obtained. Maximum pressures developed within a tank by this rapid boiling action are believed to be determined by the pressure drop in the vapor-handling system, the depth of liquid in the tank, and, possibly other operating variables. Up to the present time, the maximum pressure observed has been on the order of 2 lb./sq.in. This bumping phenomenon is receiving careful study and it now appears that it may be prevented by any agitation which produces a continuous local updraft of liquid.

How long can these stored wastes be expected to self-boil? With the operating conditions as presented in Figure 3, and on the assumption that a 500,000-gal. tank were filled with aqueous wastes from a Purex-type process producing a concentrated waste volume of about 125 gal./ton of uranium processed, the tank would be filled in 4,000 days of operating time and might be expected to boil about 50 years thereafter. If a one-million gallon tank were used, the filling time would, of course, be doubled to 8,000 days and the tank would also be expected to boil for about 70 years if heat losses per square foot of surface area are assumed equal to those of the 500,000-gal. tank. If the operating rate were increased, as in a centralized, high-capacity plant, the filling time would be correspondingly decreased, but the time of boiling would be affected very little.

PREVENTION OF BOILING

It is possible, of course, to design and operate storage facilities in such a way that the wastes are prevented from boiling. This may be done in one of two ways: first, the addition of fission products to a given tank can be so timed that the rate of heat generation within that vessel is limited to a rate less than that at which the heat can be dissipated to the soil at a temperature less than boiling. This operating technique requires a large number of storage tanks receiving small incremental additions of fresh wastes. Second, the storage tank may be designed with sufficient heat-exchange surface to remove the heat via cooling water. Such a design increases the cost of waste storage, not only by increasing the capital investment but also by storing the wastes at a higher volume per ton than would be obtainable by self-concentration techniques. The net effect is to increase the cost of waste storage per ton of fuel processed by a factor of 2 to 4. The prevention of boiling by limiting the gross rate of decay of the fission products stored in a given vessel results in a design featuring a large surface-to-volume ratio. This feature may be obtained by constructing a large number of small tanks or by designing large-diameter shallow tanks. Another alternative is to build quantities of large tanks and fill them with wastes so highly diluted that the heat generated can be dissipated to the ground. Any one of these alternatives results in an increased cost per unit of fuel processed, and justification is questionable provided the self-boiling tanks may be demonstrated to provide adequate safety.

EVALUATION OF POTENTIAL HAZARDS

The hazards of storing highly radioactive aqueous wastes in buried tanks lie in the potential release of fission products to the environs in such a way that irradiation of, or ingestion by, operating personnel or the general public might ensue. Such a release might possibly result from the rupture of a tank, either by corrosion or by the development of excessive pressures within the tank, or by the ejection of a portion of the tank contents as a mist. These potential causes of contamination spread have been examined and are believed to be controllable by reasonable design and operating precautions. For example, the corrosion rate of mild steel in the vapor

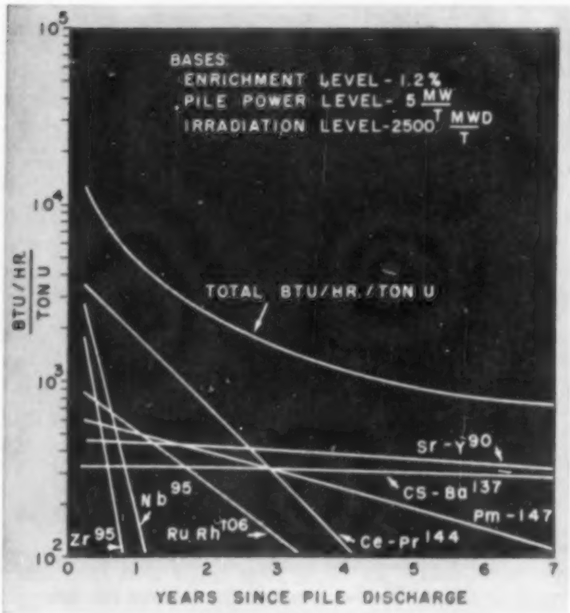
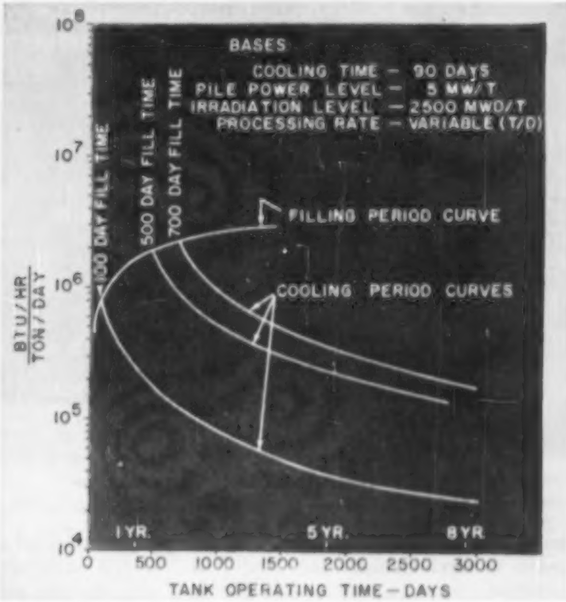


Fig. 2. Heat generation in slightly enriched uranium. Total and some specific fission product contributions. ◄



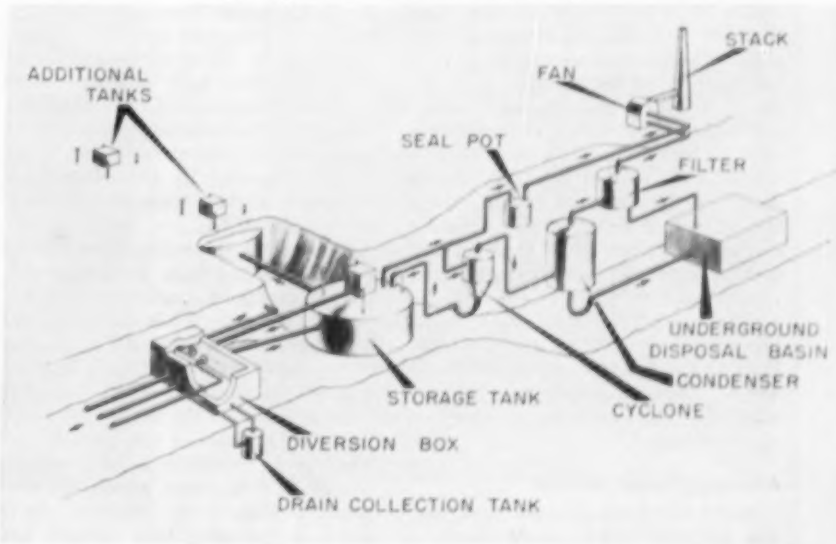
► Fig. 3. Heat generation in separations waste storage tanks.

phase of a boiling waste tank has been experimentally determined to be on the order of 10^{-4} in./month, and the corrosion rate below liquid level to be on the order of 10^{-5} in./month. These corrosion rates predict a life expectancy of at least 100 yr., although the steel *above liquid level* may become porous much sooner. The design and construction of reinforced concrete tanks with mild steel liners is a project with which normal industry is quite familiar. Within the Hanford Atomic Products Operation, some of these vessels have been emptied after ten years of service and examined as well as was possible in the residual radioactive field. The mild steel liner showed little sign of attack, and, in many cases, the prime coat of paint was still intact.

But what about this bumping action? Can it produce sufficient pressures to rupture a vessel, or can droplets of the radioactive solution be ejected with the vapor and so contaminate the vicinity? With respect to the maximum pressure, the vessel may be constructed to withstand the maximum possible pressure which might be developed. This condition is met if the tank dome is constructed to withstand a maximum vapor pressure equal in pounds per square inch to the maximum hydrostatic head normally exerted at the base of a filled tank and if the walls and base of the tank are designed to withstand this vapor pressure plus the hydrostatic head normally exerted at that point. This design assures that the tank will not be overstressed since, in the worst conceivable case whereby a layer of liquid at the bottom of the tank is heated to its boiling point at that hydrostatic head and is then suddenly transported to the top of the vessel, the maximum vapor pressure it could produce would be equal to the hydrostatic head which existed on that liquid prior to its transport. Current data indicate that other relationships will actually limit the maximum pressure developed in any vessel to some value considerably less than this limit, but the data are not yet sufficient to define these lower limits.

With respect to the ejection of tank liquids by entrainment, this problem is a simple engineering one involving the deentrainment of mists and is one with which the chemical industry has a well-developed technology. Although the degree of deentrainment required may be greater than that normally required in industrial applications, the actual performance required in a given case is determined primarily by the topography

Fig. 4. Typical high level waste storage facility.



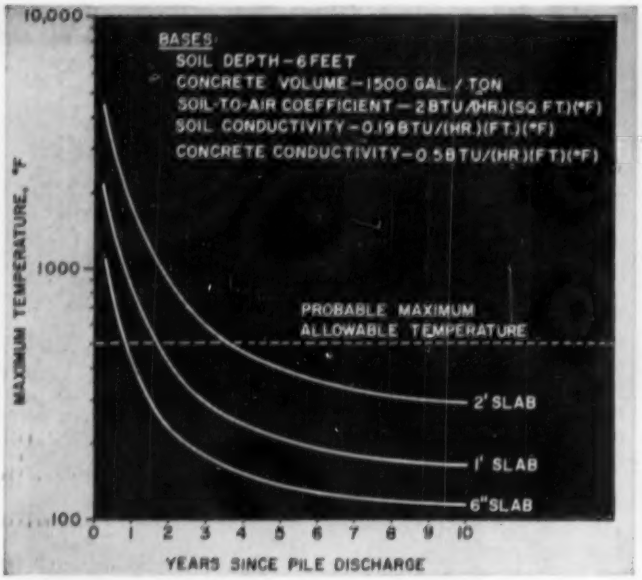


Fig. 5. Maximum temperature in buried concrete.

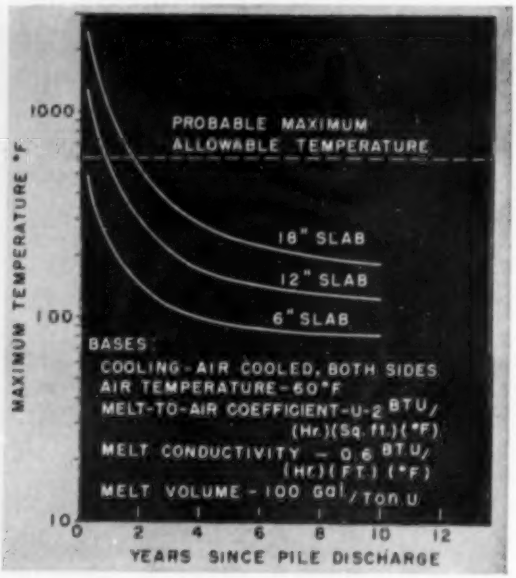


Fig. 6. Maximum temperature in air-cooled salt melts.

under consideration, and the technology exists to meet virtually any conditions required.

Another potential hazard arises from the decomposition of water and other chemicals under the intense irradiation of the waste. Hydrogen and oxygen are among the products to be expected. In a vigorously boiling vessel, the formation of these gases is of little concern since the vessel is constantly blanketed by an inert gas-steam. In a vessel which is at an elevated temperature but not yet boiling, a hazardous mixture of hydrogen and air could conceivably be formed. Analyses of the atmosphere within such tanks at Hanford have shown that hydrogen is less than one-tenth the concentration of its lower explosive limit.

Should the decision be made to limit tank boiling by the use of cooling coils, additional hazards are introduced. First the vessel must be protected from excessive pressures by designing it to permit boiling at the maximum forecastable rate, or backup facilities must be provided to assure that the tank may be cooled in the event of coil failure or loss of cooling water supply. Second a cooling-coil failure could result in contamination of the cooling water and provisions must be made to eliminate the possibility of contaminated cooling water being discharged in a manner that allows its movement to natural bodies of water. These provisions can be made with the accompanying increases of waste storage costs.

Alternate Disposal Methods

In the search for alternate waste storage methods which would result in either increased safety or decreased cost, several alternate methods have been suggested and partially developed. These include the use of pits lined with asphalt or other impervious materials in lieu of steel and concrete tanks, the incorporation of fission products in solid materials such as concrete or glass, and the storage of the fuel element itself without chemical processing after a high degree of burnout. These alternate methods encounter complications because of the self-heating characteristics of the wastes. For example, the use of asphalt to line pits becomes questionable when it is recalled that slurries of radioactive wastes tend to settle on standing, with the resultant concentration of fission products near the bottom of the container. This results in a higher rate of heat generation in the sludge layer where heat dissipation is limited by restricted convection currents. Temperatures in excess of 350° F. have been measured under such conditions and still higher temperatures would probably be produced by the more intensely radioactive wastes of the future. The integrity of asphaltic-type compounds at these temperatures is certainly questionable.

If the radioactive solutions are utilized as the liquid in casting a concrete slab, a reasonably good fixation of the fission products results. While some leaching of fission products from such a slab may be predicted, the rate of such leaching may well be tolerable. The self-heating characteristics of the wastes, however, limit the thickness of the concrete slab which could reasonably be cast as a unit because of a maximum permissible temperature within the concrete above which it dehydrates, loses strength, and eventually disintegrates. In Figure 5 these relationships are presented to show the rather severe limitations on the thickness of a buried concrete slab when incorporating young wastes. While this method appears feasible for older wastes, an interim storage of 3 to 5 years appears to be desirable to permit the decay of the short-lived fission products, and the net advantage accrued from removing the wastes and rehandling them is not clear cut.

Another possibility explored involves the incorporation of the fission products into a fused mass which, when cooled, forms a glass. This process also suffers the same type of limitation as concrete since the thermal conductivity of glass is relatively low and rather steep temperature gradients are created in the mass. This process has not appeared attractive from this and from economic viewpoints.

The feasibility of removing all volatile components from the salt waste has been considered with the storage of the salt as a melt or as the oxide. In this case, high-temperature gradients are again encountered as indicated in Figure 6. This figure assumes a melt of sodium nitrate contained in an air-cooled shallow pan. The burial of such a unit would restrict the thickness required to maintain a given temperature to values considerably lower than those indicated here. Since a cake of this type is susceptible to leaching by the action of ground waters, it would probably have to be contained in a metallic tank in any event, and thus the potential economic advantage would probably be limited to the decrease in volume relative to its volume as a boiling aqueous solution or

thin slurry. For a typical waste composed primarily of sodium nitrate, the volume decrease obtained by solidifying or calcining a saturated boiling solution is limited to about 20%, or a 50% reduction might be obtained if the salt were melted without calcination. This volume decrease is probably not sufficient to justify the additional capital and operating expense of the dryer or calciner.

One attractive possibility exists—the storage of the irradiated fuel element without chemical processing. In this scheme, the value of residual fissionable materials is balanced against the cost of constructing and operating the recovery facilities. Should a fuel-element design and operating scheme be developed which would make this plan economically feasible, the storage of the fuel element would be a relatively simple procedure, although the element would have to be cooled by placing it in a heat sink such as a water basin or an extended-surface metallic container to prevent its melting and possibly igniting from its own self-generated heat.

Removal of Long-lived Fission Products

In the foregoing discussion, generation of heat in the stored wastes has been presented as a problem of long duration. While this is true of the mixed fission products as they are formed in the pile or in the reactor, the heat generated after five years of storage is almost entirely due to the cesium and strontium present. If these two elements were chemically removed from the radioactive waste, then the disposal of the residual wastes could be treated as a short-term operation. For example, Figure 7 presents the heat generated from wastes equivalent to one ton of uranium under the assumed reactor operating conditions, both with and without the cesium and strontium being removed. While the removal of these two radioisotopes has little effect on the rate of heat generation after short cooling, it has a marked effect on the rate of heat generation after a few years of storage. Figure 8 presents the effect of their removal on the rate of heat generation from a waste storage tank under the assumed operating conditions presented earlier. It can be noted that the maximum heat generation rates obtained under these operating conditions are essentially unchanged by the removal of cesium and strontium but upon their removal the tank contents may be expected to boil only 2 to 5 years after the tank is filled. The practical effect of this change is to reduce the design requirements on the tank and to place a practical limitation on the length of time the storage tank will require close operating attention.

The cesium and strontium would probably be contained in a volume perhaps one-fifth to one-tenth that of the unscavenged waste, and the problem of removal of heat from this cesium-strontium concentrate would remain. Should a market exist for these radioisotopes by this time, they could be sold and thus this operational problem would be eliminated. If, however, no market exists, the reduced volume would permit the use of more elaborate equipment at an increased cost per unit volume for the storage facility without an increase in the net cost of waste storage per unit of fuel processed.

After interim storage and the removal of the long-lived cesium and strontium, the residual nonboiling aqueous wastes might then be stored semipermanently in the soil at some isolated location. These wastes would contain relatively little radioactivity, and their transport via lightly shielded tank cars could probably be effected at reasonable cost. The storage of these wastes in the soil assumes a soil having sufficient ion-exchange capacity to retain the fission products, and a location featuring minimum rainfall and maximum distance to the water table.

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Fig. 7. Effect of Cs^{137} and Sr^{90} removal on heat generation.

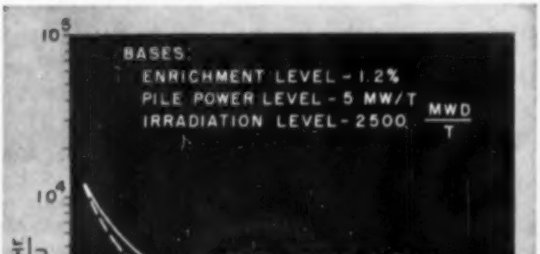
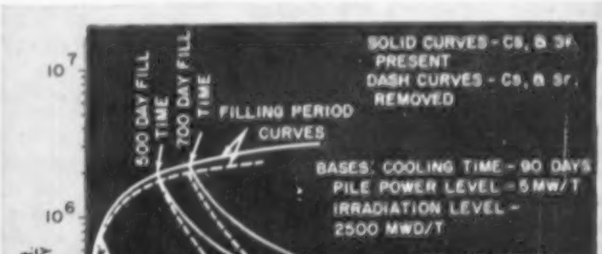


Fig. 8. Effect of Cs^{137} and Sr^{90} removal on heat generation in storage tanks.



What's In

Symposium Series Volume 51

(Number 17, 1955—"Heat Transfer")

Surface Variables in Nucleate Boiling

Claude Corty and Alan S. Foust

Measurements were made of the nucleate boiling coefficients of ether, normal pentane, and Freon 113 from a horizontal heated surface. Profilometer measurements of roughness and photo- and electron-micrographs of the surfaces were taken. Boiling bubbles were photographed in profile, and active centers were counted.

The experiments indicate a major influence of microroughness on the ΔT necessary to sustain nucleate boiling at any given heat flux.

A pronounced hysteresis effect was observed. While increasing heat flux, the ΔT is higher than that necessary to accommodate the same heat transfer when the flux is being decreased.

Based on these observed phenomena, a vapor-trapping mechanism of nucleate boiling has been postulated.

By use of this postulated mechanism it has been possible to explain why large differences may exist in the slopes of the nucleate-boiling curves and in their position. The theory shows why superheat is necessary in boiling and why it has been impossible to predict with any accuracy the ΔT required to produce a desired nucleate-boiling heat transfer coefficient in untested metal-liquid systems.

Effect of Gas Evolution on Surface Boiling at Wire Coils

F. P. Pike, P. D. Miller, Jr., and K. O. Beatty, Jr.

The effect of gas evolution on surface boiling was investigated experimentally by use of water and glycerin with dissolved air and carbon dioxide. The presence of a dissolved gas was found to initiate surface boiling at lower surface-to-liquid temperature differences than did degassed liquids. The saturation temperature of the gas-liquid solution was found to be controlling. The results support the hypothesis that the marked effectiveness of surface boiling is the result of mechanical action rather than latent heat effects.

It is concluded that dissolved gas is an important variable in surface boiling. The addition of dissolved gas brings about the onset of surface boiling at lower surface-to-liquid temperature differences than otherwise. During surface boiling the controlling temperature difference is that between the heated surface and the saturation temperature of the gas-liquid system. It is more pertinent to measure the quantity of the dissolved gas by the resultant saturation temperature under run conditions than by the quantity per unit volume.

Stable Film Boiling of Liquid Oxygen Outside Single Horizontal Tubes and Wires

J. T. Banchero, G. E. Barker, and R. H. Boll

Heat transfer coefficients for liquid oxygen boiling outside single horizontal tubes and wires were measured in the stable film boiling region. The difference between the heated-surface and the saturation temperatures of the liquid was varied from 100 to 700° F., pressure was varied from 5 to 500 lb./sq. in. abs., and the diameters used ranged from 0.025 to 0.750 in. The Bromley correlation was found to predict the effects of temperature difference and pressure for the entire range of variables but does not correctly predict the effect of diameter over the entire range. The experimental values of the coefficient were found to vary as $(1/D + \text{constant})$.

Stable film boiling coefficients for liquid oxygen are not significantly affected by surface material.

Generation of Steam from Liquid Metal at High Heat Fluxes

E. C. King and R. C. Andrews

The performance of specially designed double wall stainless steel tubes was compared with that of a single wall tube in the generation of steam at high heat fluxes. Sodium-potassium alloy in the tubes was the heat transfer medium.

Heat was transferred at fluxes as high as 450,000 B.t.u./(hr.) (sq. ft.) at steam pressures between 113 and 1,203 lb./sq.in. abs. The over-all heat transfer coefficients ranged from 412 to 1,306 B.t.u./(hr.) (sq. ft.) (° F.).

Evaluation of the tube design and bond resistance was made and a method for calculating the performance of such tubes is presented.

The performance of double wall tubes has proved the feasibility of a safety feature that could save considerable trouble should a leak develop in a tube in a steam generator using an alkali metal as the heat transfer fluid.

By using the method presented here for calculating the bond resistance and by using the values of the bond resistance and outside resistance, one should be able to estimate with a fair degree of accuracy the performance of any tube of similar design.

Boiling Heat Transfer with Liquid Metals

Robert E. Lyon, Alan S. Foust, and Donald L. Katz

Boiling heat transfer coefficients were measured for mercury, mercury plus 0.1% sodium, and mercury 0.02% magnesium and trace of titanium, sodium, sodium-potassium alloy, and cadmium at temperatures from 670 to 1,600° F. and atmospheric pressure. The temperature differences were measured by thermocouples in the tube wall and in the bulk of the boiling liquid. The highest coefficients were for sodium and sodium-potassium alloys—up to 15,000 B.t.u./(hr.) (° F.) (sq. ft.). The combination of low coefficients with pure mercury and high coefficients with addition agents are interpreted as film and nucleate boiling, respectively. It follows that film boiling may be more the result of nonwetting characteristics of the surface than of heat flux or quantity of vapor evolved.

Melting of Solids

T. K. Ross

A formula is derived for computing heat transfer to a melting solid separated from the heat transfer surface by the melted solid. The liquid is assumed to be in steady state laminar flow from between the melting solid and the heat transfer surface. Exeprimental data confirm the formulation.

("Heat transfer" to be continued.)

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Mineral Engineering Techniques

(Vol. 50, No. 15, 1954)

Laboratory Procedures for Flotation Testing in Chemical Engineering Problems

G. Gutzeit

Froth flotation has been developed in the mineral industries and more than 80% of all ore concentration is accomplished by this method. It is based on differences in the surface properties of solids and has a broad potential value for the solution ot many chemical engineering problems. It is difficult to predict a priori whether flotation is applicable at all or whether it would be more economical (initial equipment cost and operating expenses) than any possible alternative method. A technique is here outlined that will allow the chemical engineer with only a general background to appraise the possibilities offered by flotation in the specific case under study. Froth flotation can be helpful in at least five types of chemical engineering problems.

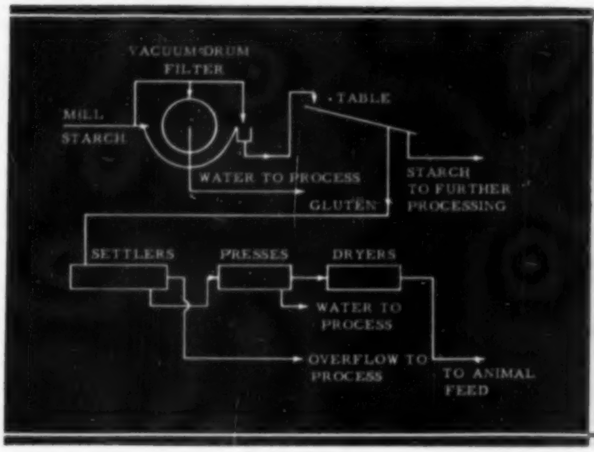

Fig. 1. Present system used to separate starch and gluten fractions and to concentrate and dewater gluten.

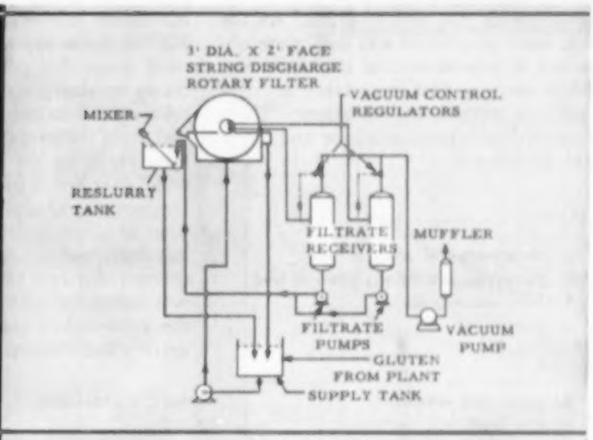

Fig. 2. Flowsheet for pilot plant filter station.

continuous rotary filtration of

CORN GLUTEN

Studies are being made by the Corn Products Refining Company to determine proper design for the modernization of the Argo, Illinois, plant-feed house. Investigations were made on the application of continuous filtration to the dewatering of gluten and/or fiber. The study also included an analysis of all variables affecting filtration so that economic examinations of the entire flowsheet could be made. This paper will cover the experimental program and the analysis of the data obtained from the filtration of gluten only. However, the program and methods of handling the data for gluten and fiber or fiber alone are similar to those outlined herein.

Bern A. Schepman, Byron Martin,† and Donald A. Dahlstrom ‡*

Corn Products Refining Company, Argo, Illinois.

As is true of many of our older and well-established industries, the processes and equipment used in the corn wet milling industry are constantly being improved and modernized. The basic operation at the Argo plant for the separation, concentration, and dewatering of the starch and gluten fractions at the time of this study is shown on Figure 1 (*3*). However, the entire process is being examined, and undoubtedly many changes will be made in the future. The principal gluten and starch separation is now made on tables after which the gluten is settled for about 24 hr. prior to filtration in plate and frame presses. The dewatered gluten discharged from the presses is fed to rotary dryers where the moisture is reduced to the desired level. The dried gluten is then blended with carbohydrates, fats, and fiber in the proper proportions to produce animal feeds.

Although the plate filter presses now in use have the advantages of being able to operate successfully with dilute gluten slurries and to produce filter cakes of slightly lower moisture contents, they have several disadvantages compared to continuous filtration. Labor costs are high since several men per shift are required to remove the solids from the presses. Cloth life is relatively short and fairly frequent cloth removal is necessary to wash or replace those cloths that are not suitable for further use.

Although the savings in the cost of labor and cloth will be sizeable with continuous filtration, other factors affecting the decision to replace the presses will also be influential. Working conditions and sanitary problems would be improved. Higher drying efficiencies should be obtained with continuous filtration due to the handling of thin strips of cake of uniform moisture content. With the presses, however, large masses of varying moisture content tend to ball and do not dry readily.

The majority of the protein in the corn kernel is present in the gluten fraction (*4*). Gluten has the properties normally associated with proteinaceous materials. The solids in suspension do not settle readily and have the slime characteristics of long-chain molecular materials. The properties were primarily responsible for the decision to employ a continuous string discharge drum filter in the experimental work. The thin "tacky" gluten filter cake would be difficult to discharge with a doctor blade. Gluten cakes of only ⅛-in. thickness will discharge cleanly with strings. This eliminates the possibility of smearing solids into the filter cloth and thereby causing blinding.

Basic Variables in Gluten Filtration

Nine basic variables, affecting filter

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production and cake moisture, were evaluated in the test program. As the test work progressed and data were obtained, it became evident that four variables were of first importance and five could be considered secondary. These nine variables listed as major and minor are as follows:

MAJOR

1. concentration of solids in feed
2. percentage protein (dry basis) in feed
3. drum submergence
4. drum speed

MINOR

5. initial form vacuum
6. filter medium
7. feed temperature
8. cu.ft./min. air/sq.ft. filter area
9. compression rolls

All these variables were considered for their effect on the dry solids rate from the filter and on the moisture content of the filter cake. It should be noted that factors 1 and 2 are functions of the upstream process steps and demonstrate the close relationship of the complete flowsheet in determining optimum economics.

Test Program

The filter station flowsheet is pictured in Figure 2 and was designed to obtain maximum flexibility. An Eimco 3-ft. diam. by 2-ft. face string-discharge filter was employed with practically all equipment (Figure 2) installed on one platform. Measurements or observations of all nine variables as well as cake production rate and moisture contents could be made easily.

MAJOR VARIABLES

The greater part of the test program consisted of drawing a batch of feed from the plant at measured protein percentage and feed solids concentration, and of operating the filter that same day on this feed by recycling the filtrate and repulping the cake. Drum speed was tested at 10, 7.5, 5, 3, 2, and 1.5 minutes per revolution at various intervals throughout the day with duplicate data taken for each condition. Protein percentage and feed solids concentration were always measured for each run and data reliability checked by material balances. Any change in feed quality was observed by repeating the same initial filter operating conditions at the end of the day's test work.

The effect of feed solids concentration and protein content was investigated by changing the type of gluten drawn from the plant each day. Feed-temperature studies were performed by installing a plate heat exchanger in the feed line. Maximum temperature was limited to 125° F. since any starch present would swell above this point and cause an increase in slurry viscosity. Compression rolls were installed to study their effect, and drum submergence was investigated by controlling the height of the filter tank overflow. Initial cake-formation vacuum was examined by operating the filter at constant drum speeds and varying form vacuum under controlled conditions. Air rate through the filter cake was measured by an orifice installed in the vacuum line between the filtrate receivers and vacuum pump.

MINOR VARIABLES

Prior to the pilot plant work, filter-leaf test studies were made to determine the optimum filter media. These studies indicated that two nylons and a cotton twill would yield dependable results. However, the nylons were eliminated in the pilot plant as definite blinding characteristics were revealed. The cotton twill, on the other hand, did not blind over long periods of operation and, therefore, all data were taken on this medium. Long test runs of several days were also performed so that all basic data could be corrected for any partial blinding.

During the test work, it became apparent that certain of the variables could be eliminated from further consideration. Either economics did not justify their alteration—they could not be practically applied—or their optimum operating level could be rapidly established.

Because of the slimy nature of gluten, there was a possibility that lower initial form vacuums might increase filtration rates. This would be caused by a better bridging action on the filter media such that bridging occurred on the surface rather than within the cloth. However, extensive tests indicated that filtration rate increased consistently with an increase in initial form vacuum. Since initial form vacuum has little effect on vacuum pump capacity, economics would easily justify the employment of high values.

Tests made at controlled feed temperatures from 80 to 124° F. indicated only a slight increase in filtration rate of approximately 5% for a 20° F. increase in feed temperature. In addition, cake moisture content was only lowered a negligible amount with an increase in temperature. An economic analysis indicated that the advantages were too small to justify the installation of heat exchangers and the operating expense involved.

The filter was provided with facilities to allow the use of compression rolls at varying pressures. Based on previous experience, it was expected that the gluten cake was too "tacky" for such operation. The rolls were tested under various combinations of operating conditions, and the original suppositions were found to be true. Cake was picked up from the drum by the rolls. Hence rolls could not be employed successfully.

Data taken on air rate measurement indicated that between 1.4 and 2.4 cu.ft./min. of air, measured at vacuum per square foot of filter area, will be required depending on final design conditions. The higher air rate occurred while filtering low concentration slurries with resulting thin cakes which cracked readily. It was thought that air rate would have a marked influence on cake moisture content. However, no significant relationship between air flow and either cake thickness or cake moisture could be established. This phenomenon probably is due to the cake cracking when dewatered and the high ratio of system volume to air actually pulled through the cake for a filter of this size.

Effect of Major Variables on Filter Rate

As noted previously, drum speed and submergence, % protein in the feed, and feed solids concentration were of major importance in affecting cake moisture and filter production. In order to make the most effective analysis of the relationships between these variables and the dry solids rates, the fundamental dynamic filtration expression shown as a modification of Poiseuille's equation was considered (*1, 2*).

$$\frac{dV}{A d\theta_f} = \frac{(-\Delta P)}{\mu\left[\alpha(-\Delta P)^s \frac{wV}{A} + r\right]} \qquad (1)$$

where

V = volume of filtrate collected
θ_f = time of filtration or form time
A = filtration area
μ = filtrate viscosity
$-\Delta P$ = pressure drop
s = filter cake compressibility factor
α = specific cake resistance at $-\Delta P = 1.0$
w = weight of dry cake solids per unit volume of filtrate
r = resistance of filter system ex cake (includes filter media, lines, etc.)

By assuming that r, as defined above, is negligible (a valid assumption for these conditions), and that filtrate viscosity and specific cake resistance remain constant as the cake is formed, the equation can be integrated for constant pressure filtration as follows:

$$\frac{V^2}{A^2} = \frac{2(-\Delta P)^{1-s}\theta_f}{\mu \alpha w} \qquad (2)$$

Since W in dry weight of cake $= wV$, one can substitute for V^2 and combine 2, μ, α, and w into one constant $= C$ and obtain the following:

$$\frac{W}{A} = [C(-\Delta P)^{1-s}\theta_f]^{1/2} \tag{3}$$

Since Z in

$$\frac{\text{lb. dry solids}}{(\text{hr. form time})(\text{sq.ft.})} = \frac{W}{A} \times \frac{60}{\theta_f}$$

if θ_f is expressed in minutes, substituting for W/A and combining C and 60 into another constant $= K$,

$$Z = K\left[\frac{(-\Delta P)^{1-s}}{\theta_f}\right]^{1/2} \tag{4}$$

All data were tested to determine if this relationship between Z, the dry solids form rate, and θ_f held true. It was necessary to use data in rather narrow ranges of solids and protein concentrations in the feed, since a change in these variables affects the dry solids rate by virtue of the change in w as well as the probable change in α. It can be seen from Figure 3 that a typical plot of the log of Z vs. the log of form time yields a slope of -0.50 as was expected. By the use of this relationship, all the data could be corrected to one form time for the analysis of the effect of feed concentration; thus, the effect of both drum speed (cycle time) and drum submergence was eliminated since their combined effect on filtration rate is actually expressed in filtration form time.

All dry solids rates from the filter then were corrected to 1.5 min. form time by using the relationship shown on Figure 3, that is,

$$\left(\frac{Z_1}{Z_2} = \left[\frac{\theta_{f_2}}{\theta_{f_1}}\right]^{1/2}\right)$$

These rates expressed as pounds per hour form time per square foot corrected to 1.5 min. form time were plotted against gluten concentration in ounces per gallon for different ranges of protein concentration. Since it is expected that the operating range of the filters will generally be from 60-70% protein (dry basis), only these graphs will be included to illustrate the various relationships. It can be seen from Figure 4 that the data form a rather well-defined relationship within the gluten concentrations of 12-20 oz./gal. Twelve to 20 oz./gal. represents the probable operating range for the future installation even though good operation can be obtained from 9 to 24 oz./gal. Below 9 oz./gal. form times become excessive in order to form a reasonable cake for good discharge and the filter rates decrease sharply. Above 24 oz./gal., the viscosity of the material increases such that pumping and handling are extremely difficult.

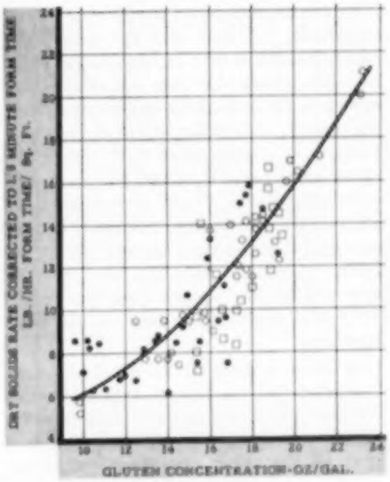

Fig. 4. Dry solids rate based on form time corrected to 1.5 min. form time as function of gluten concentration filtration of corn gluten. Bases: 1. ● 50% submergence; 2. ○ 35% submergence; 3. □ 25% submergence; 4. Filter medium-cotton twill; 5. Protein concentration 60-70%.

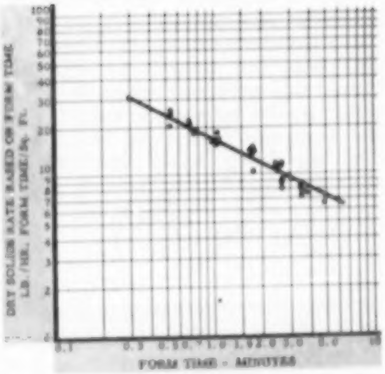

Fig. 3. Dry solids rate based on form time as function of form time filtration of corn gluten. Bases: 1. Data obtained at 35 and 50% submergence; 2. Filter medium—cotton twill; 3. Gluten concentrations between 16.7-18.8 oz./gal.; 4. Protein concentrations between 70.1-76.2%.

From the smoothed average curve of form rate corrected to 1.5 min. form time vs. gluten concentration, data were calculated to plot the filter production in lb. dry solids/(hr.)(sq.ft.) vs. gluten concentration for each submergence (25, 35 and 50%) with parameters of drum speed. Figure 5 shows the curves for 35% submergence. This type of plot is more useful from an operating or economic standpoint in that rates for any combination of different operating conditions can be obtained readily from this graph. These dry solids rates, combined with the cake moistures which can be expected for the corresponding conditions, give the data needed for any type of economic analysis. The shaded area to the left represents the area of operating conditions which are not considered practical for full-scale plant operation since the cake will be too thin for reliable, complete discharge.

String discharge rotary filter.

Effect of Major Variables on Cake Moisture

The principal variables controlling filter cake moisture content and a method of expressing cake moisture as a function of a correlating factor previously have been outlined by Silverblatt, Dahlstrom and Emmett (*5, 6*). Although this work was done with a different type of material, it was felt that the same principles could be applied. The correlating factor developed in their work was:

$$\frac{\text{cu.ft./min.}}{\text{sq.ft.}}\,(\theta')\left(\frac{-\Delta P^{1/2}}{d}\right)\frac{1}{\mu}$$

where

$\frac{\text{cu.ft./min.}}{\text{sq.ft.}}$ denotes standard cubic feet (32° F. 1 atm.) of air drawn through 1 sq. ft. of cake/min.

θ' = drying time, min.

$-\Delta P$ = vacuum of drying zone

d = cake thickness

μ = filtrate viscosity

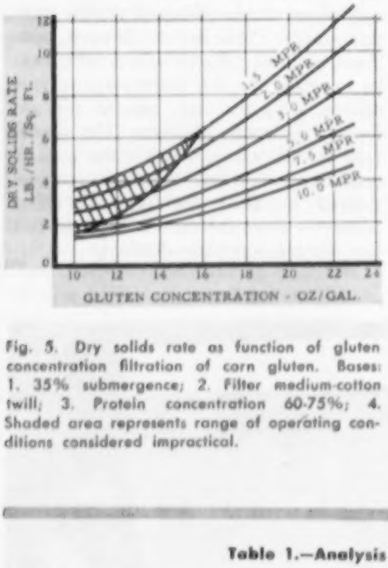

Fig. 5. Dry solids rate as function of gluten concentration filtration of corn gluten. Bases: 1. 35% submergence; 2. Filter medium-cotton twill; 3. Protein concentration 60-75%; 4. Shaded area represents range of operating conditions considered impractical.

In the present tests, μ and $-\Delta P$ were essentially constant and the data indicated that there was no significant relationship between air rate and either cake moisture or cake thickness as discussed previously. Accordingly, the correlating factor was simplified to θ'/d. Since the cakes were quite thin and the measured values for d would have introduced considerable error of measurement, it was assumed that the cake density would remain essentially constant and pounds dry solids per square foot per cycle (d') was used as a measure of cake thickness.

A close inspection of the daily runs indicated that the cake moistures for the first and the last two runs each day differed considerably in spite of the fact that all the other operating conditions were kept nearly constant. The daily test programs were designed to reveal such trends and normally two 5 min./rev. runs were made at the beginning and end of each day (around 9:00 A.M. and 2:30 P.M.). Experience with the filtration of other materials in which the filter cake had been reslurried (such as was done during these tests) had shown that cake moistures generally increased over a period of several hours' operation. As the variation characteristic of these data would provide the most objective standard for testing the significance of the difference between the 9:00 A.M. and 2:30 P.M. runs, an analysis of variance was used to summarize the data and provide tests of significance. The dry solids rates for these specific runs were also included to insure the reliability of using all the rate data as has been done.

Table 1 shows the two analyses of variance tables. Even though the sum of squares of the day-to-day variation is large, it is meaningless due to the wide changes in gluten and protein concentration. It can be seen from the comparison of the F value (variance ratio), obtained from the data with the values required at the 1 and 5% levels, that the effect of time on the cake moistures is highly significant. It can be seen also that the opposite is true of the variance between the dry solids rates at 9:00 and 2:30 o'clock. The F value in this case was less than 1.0 which indicates no significance (*7*).

Only the average of the first two pairs of test runs each day, based on this statistical analysis, were considered for the correlations for the short-term runs. The data then were divided into 60-70% protein, 70-75% protein, and over 75% protein groups, and the cake moistures plotted against θ'/d'.

Good correlations were obtained as can be seen from Figure 6 which shows the data obtained in the 60-70% protein range. There was a difference of approximately 1% in cake moisture between the 60-70% and the 70-75% protein ranges; hence, the data were handled separately. The lines for the two lower protein ranges were nearly parallel while the data over 75% gave a line of a considerably different slope as can be seen on Figure 7. The least squares procedure for estimating a linear regression was used to draw the three lines and the data yielded unusually high coefficients of correlation of 0.87 for the 60-70% range, 0.83 for the 70-75% range, and 0.87 for the over 75% range. These high coefficients indicated that the relationships were significant since the 1% point for the three regressions were all under 0.60.

In order to convert these test data to plant-type operation and to present it in a form similar to the rate curves, Figure 8 was prepared from the correlations for the 60-70% protein range. It was realized that the relationship as shown on Figure 7 is actually discontinuous at about 59% cake moisture. At this moisture level the cake cracks and no more reduction is obtained with longer drying time. Figure 8 was drawn in order to illustrate this clearly by making the curves asymptotic in the lower moisture range. The exact minimum moisture could not be fixed from these data, but it is not important in the economic analysis as the filters will operate in a higher range of cake moisture to take advantage of the corresponding higher dry solids rates.

Table 1.—Analysis of Variance Table

Moisture analysis

Source of variance	Sum of squares	Degrees of freedom	Mean square	Variance ratio F	F Required at 5%	1%
total	994.614	99	......	....	....	....
days	855.730	49	17.45		No Meaning	
time	36.125	1	36.125	17.2	4.04	7.19
days-time*	102.759	49	2.098	....	....	....

avg. % moisture at 9:00 a.m.—63.97
avg. % moisture at 2:30 p.m.—64.82

Rate analysis

Source of variance	Sum of squares	Degrees of freedom	Mean square	Variance ratio F	F Required at 5%	1%
total	365.6674	99	......	....	....	....
days	349.9076	49	7.130		No Meaning	
time	0.1086	1	0.109	0.342	4.04	7.19
days-time*	15.6512	49	0.319	....	....	....

* residual.

Application of Correlations to Economic Analysis

It readily can be seen that the manner in which the data have been presented will allow a quick and simple economic analysis around the filter station. From the other phases of the studies, data will be available on the investment and operating costs of the separating and con-

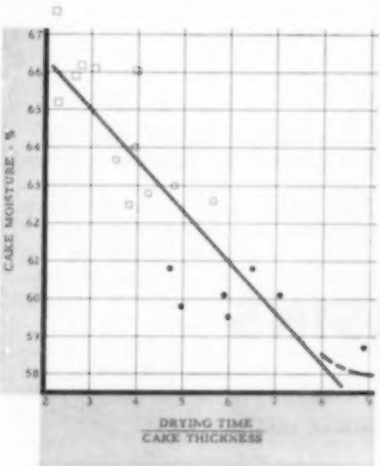

Fig. 6. Cake moisture as a function of correlating factor—θ'/d', filtration of corn gluten. Bases: 1. □ 50% submergence; 2. ○ 35% submergence; 3. ● 25% submergence; 4. Protein concentration 60-70%; 5. Data at all gluten concentrations; 6. Filter medium-cotton twill.

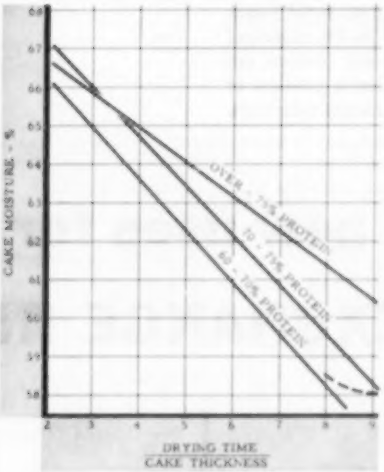

Fig. 7. Cake moisture as a function of correlating factor—θ'/d', filtration of corn gluten. Bases: 1. Data at all gluten concentrations; 2. Filter medium-cotton twill.

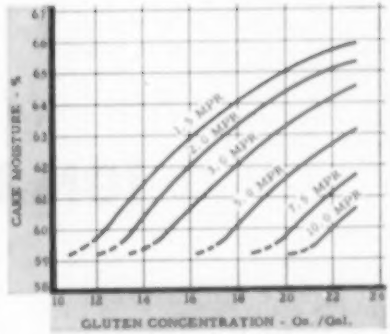

Fig. 8. Cake moisture as function of gluten concentration as predicted for full-scale plant operation. Bases: 1. Filter medium-cotton twill; 2. Protein concentration 60-70%; 3. 35% submergence.

centrating equipment required to produce gluten of a given protein concentration. It then will be possible to obtain from the curves on Figures 5 and 8 the dry solids rates and cake moistures which can be expected for any given set of conditions. From these rates the sizes of the filter station for any particular conditions can be determined easily, and from the corrected moistures the dryer loads can be calculated. A complete economic balance, based on these figures, can be made, and the investment and operating costs for the filter station and other equipment selected to yield the desired design criteria.

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techniques

TRAILER-BORNE INSTRUMENTS CHECK PLANT EFFLUENTS

Automatic recorders in specially designed trailers rove from plant to plant in Charlotte, N. C., testing discharge of industrial wastes.

Two trailers equipped to make 24-hour tests of plant effluents by continuous *p*H measurements, flow rate, and total volume of flow are maintained by the Charlotte Water Department. Key to the effectiveness of this mobile equipment is a new compact *p*H recorder manufactured by Leeds and Northrup.

Strict Regulation

City regulations require that the effluent from any plant discharging more than 40,000 gallons per day be checked every 90 days. In addition, any corrosive mixtures, however small, which are detected at disposal plants, must be traced to their source, and the responsible plants notified.

Former Facilities Overloaded

Tests have to be made for over 60 manufacturing plants and involve about 500 miles of sewer lines spread over approximately 45 square miles. By manual sampling and checking methods, this was a burdensome and time-consuming task. The mobile trailers with automatic recorders were adopted to speed the checking job with a minimum of manpower.

Test Procedure

Use of automatic recorders permits the 24-hour tests to be conducted without constant supervision. The L&N Speedomax *p*H recorder plots continuously the *p*H value of the waste. At the same time, a Hagan flowmeter charts the rate of flow. An integrating device on the flowmeter records the total volume of flow for the test period. Time markings on the charts tie in accurately recorded values with the exact time of day.

The use of ion exchange materials continues to embrace a wider and wider range of applications in the chemical engineering field. Many of the uses do not involve ion exchange reactions in the strictest sense. Here is a review of some of the more interesting and important recent advances.

new uses for ION EXCHANGE RESINS

R. M. Wheaton | Dow Chemical Company, Midland, Michigan

Among the novel ion exchange reactions, the formation of metal anion complexes and their affinity for strongly basic anion exchangers have been described by various investigators since 1949 (*1*). Iron and a host of other metals form anion halide complexes of various valency depending on *p*H and halide ion concentration. In this form the metal may be picked up from solution by anion exchangers for purification of the solution or the anion exchangers may be used for the fractionation of metals present in a multicomponent mixture. One example of a commercial application is the removal of iron from concentrated hydrochloric acid in which case it has been reported that the iron content may be reduced to under 0.05 p.p.m. (*2*). Regeneration of the resin with water, or more accurately with a dilute acid solution, to prevent hydrolysis, permits removal of the metal as a cation. Effectively no chemical regenerant is required in such instances. This method should have great utility particularly in the mining and/or metal recovery field plus potential use in the purification of some of the rarer elements.

Anion sulfate exchange is a newer process (*3, 4*) whose potentialities have not been fully realized. Basically, it is a method for the removal of strong acids from aqueous solutions of other solutes by true ion exchange; however, this method involves only water regeneration.

When sulfuric acid is dissolved in water, it dissociates into hydrogen, bisulfate, and sulfate ions; the ratio of bisulfate to sulfate varies with concentration. The selectivity of ion exchangers for polyvalent ions varies inversely with concentration. Thus, if an anion exchanger in the sulfate form is placed in a column and contacted with a moderately strong sulfuric acid solution, the

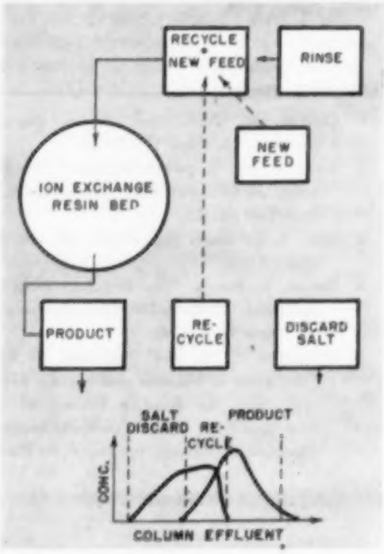

Fig. 9. Sketch of batch recycle method of ion exclusion.

resin composition changes toward the bisulfate form and at the same time produces deionized water. When the resin becomes exhausted (the ultimate capacity here will be seen to be one-half the total ion exchange capacity), it may be regenerated back to the sulfate form with water rinsing.

However, it has not been possible to recover sulfuric acid at a concentration above that in the feed; thus, the process cannot be used in straight water treatment and is limited to removal of acid from aqueous solutions of other solutes —nonionic materials or metal sulfates. An example of such a separation may be seen in Figure 1 for the removal of sulfuric acid from glycerine. Two factors should be pointed out here: (1) the resin column was considerably underloaded for a practical operation as noted by the 60 cc. water between the two fractions; (2) there is a long trailing in the rinse of acid from the resin.

Aldehydes may be picked up by anion exchange resins in the bisulfite form (*5*), by a familiar reaction in organic qualitative analysis in which the hydroxy sulfonic acid is formed, which in this case is affixed to the resin matrix. The resin may then be regenerated by successive treatment with soda ash and sodium bisulfite. The reaction is useful in the removal of low amounts of aldehydes from aqueous solution—a serious contaminant which, in many cases, contributes to odor, color, and taste problems. At least one industrial unit has been installed utilizing this process.

Ion Exchangers as Catalysts

Ion exchangers have long been considered as catalysts for reactions where strong acids or strong bases are required, and many papers have dealt with successes in the catalyzation of such reactions as acetal formation, alcohol dehydration, aldol condensation, esterification, protein hydrolysis, and many others.

How widely the resins are actually used in these reactions is not known; in many cases such information is held as closely guarded secrets by industrial firms. A few commercial applications are known; however, it is guessed that the present use is quite limited. One serious drawback of ion exchange catalysis is the temperature limitation of the organic exchangers. Operating life of cation exchangers is quite short at temperatures of over 200° C.; hydroxide-form anion exchangers are not useful except for short periods at over 100° C. In some cases other advantages of resins as catalysts outweigh their cost for a once-through operation.

The most obvious advantage of ion exchange materials as catalysts is the simplicity with which they may be removed from the reactant medium by filtration. Other possible advantages which can be referred only to the proposed operating system would include the following: (1) elimination of neutralization of the reaction mixture, (2) substantial reduction of side reactions and, thus, increased product yield, (3) reduction of catalyst cost by repeated usage of the exchanger, in many cases without regeneration, (4) reduction of catalyst corrosion problems, (5) reduction of product sensitivity to unusual *p*H because of rapid removal of catalyst.

One of the biggest boosts to the use of ion exchangers as catalysts was the recent announcement of the epoxidation reaction with vegetable oils, animal fats and their derivatives (*6*). In this case, the reaction of an unsaturate with peracetic acid is carried out with the fat, hydrogen peroxide, acetic acid, and the acid form of a cation exchanger. The hazardous peracetic acid is never isolated; the resin may be reused repeatedly, and yields are reportedly good.

Ion Exclusion and Nonionic Separations

A new use for ion exchange resins has been discovered which is not truly ion exchange in character (*7, 8*). Ion exclusion is one of several new developments involving the use of the crosslinked polyelectrolytes (ion exchange resins). Basically, ion exclusion is a method for the fractionation of electrolytes from nonelectrolytes, both present in aqueous solution, by the use of ion exchange resins but without chemical regeneration.

The swollen resin particle is a solution phase, essentially homogeneous, and limited in size only by the nature of the crosslinked structure. At a medium degree of crosslinkage this material contains a large quantity of water within the total structure and at the same time a high concentration of ion active groups. Commercially available cation exchangers used in water softening contain about 50% water by weight and have an ionic concentration of about 3 *N*.

When such an ion exchange material is placed in contact with an ionic solution, the solute distributes itself between the two solution phases—that within the exchanger particle and that surrounding the exchanger—in a manner like that which would be expected from studies of the Donnan membrane equilibrium, lending weight to this theory of ion exchange. For hydrochloric acid and a strongly acid cation exchange resin, the acid strength in the solution around the bead is roughly ten times that within the bead except at a high concentration.

On the assumption that only the charge effect enters into the exclusion of an electrolyte from the resin particle, it is believed that a nonelectrolyte would come to equilibrium at the same concentration within and around the bead. As shown later, this is not strictly true. In the general case, if a solution containing both ionic (electrolyte) and nonionic (nonelectrolyte) solutes is contacted with ion exchange resin particles, the solution around the particles becomes relatively richer in the ionic component, while that within the particle becomes relatively richer in the nonionic. This method in a series of countercurrent batch operations would make possible the eventual separation of the two components. However, this method would be laborious and impractical.

COLUMN TECHNIQUE

If, instead of a series of batch operations, a column procedure is followed similar to that used in conventional ion exchange, it becomes possible to separate the two components quite readily.

A hypothetical column with its component parts is shown in Figure 2. As a first approximation, assume that the ionic component is completely excluded from the resin phase $V^{r}_{(liq)}$, whereas the nonionic solute is equally distributed between the aqueous portions of the resin phase and surrounding solution ($V_{(liq)}$).

If to the top of the resin column a feed solution containing the two hypothetical components is introduced, the ionic solute will pass downward through the column and appear in the effluent after $V_{(liq)}$ volumes of solvent have passed through the column. Similarly, the nonionic solute will appear after $V_{(liq)} + V^{r}_{(liq)}$ volumes of liquid have percolated through the bed (Figure 3). Thus, one now has the ionic solute free of the nonionic for $V^{r}_{(liq)}$ volumes of effluent.

Then, if feed is discontinued to the resin bed and replaced by rinse water, the ionic component first will be rinsed from the column followed by the nonionic which will be free of contamination, that is, deionized. This illustration shows a great deal of cross-contamination during the larger part of the run, which at first thought seemed highly undesirable. To overcome this, one must then reduce the feed volume to less than $V_{(liq)}$ and thus have the ionic component entirely removed from the bed before the nonionic first appeared in the effluent stream.

A practical example of this is shown (Figure 4) for the separation of ethylene glycol and sodium chloride. In this case a 10-ml. solution, containing 4% by weight of each of the solutes, was passed through a 100-ml. bed of fine mesh cation exchange resin. As ex-

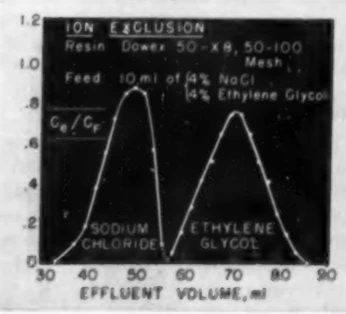

Fig. 4. Ion exclusion separation of sodium chloride and ethylene glycol.

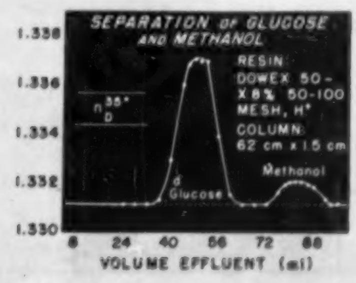

Fig. 6. Nonionic separation of d-glucose and methanol.

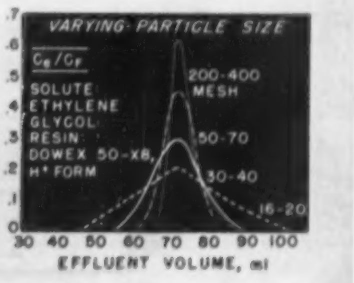

Fig. 5. Elution curves. Effect of particle size.

pected, there is a considerable deviation from the idealized square waves of the theoretical case and thus, to get complete separation, the feed volume must be considerably less than the free volume within the resin ($V^r_{(liq)}$).

Such complete separations were the object of early work in ion exclusion and the basis for much fundamental knowledge. A host of variables has been studied to determine their effect on ion-exclusion-type separations, such as:

(1) nature of the functional groups within the anion or cation exchange resins, (2) cross linkage of the resin, (3) particle size, (4) feed volume, (5) concentration, (6) solute ionization constants, (7) solute distribution constants, and (8) operating temperature and flow rates. A wide range of systems has been investigated.

Some general conclusions may be drawn on several of these factors. For example, a more highly ionized exchange resin is preferred—one that is highly ionized in the desired operating pH range. The sulfonic-acid-type cation

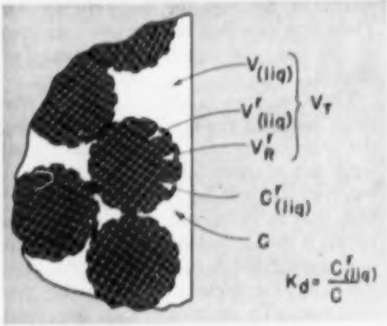

Fig. 2. Hypothetical section of an ion exclusion column.

exchangers and the quaternary ammonium salt anion exchangers are most versatile since they are operable over virtually the entire pH range. Except for wide variations, the effects of changes in crosslinkage are not great. Lower crosslinkage gives faster diffusion which becomes more important with highly associated molecules like glycerine. On the other hand, the exclusion of the ionic component is reduced at the same time and a compromise must be reached. An added factor is the problem of resin volume change and pressure drop with the low crosslinked resins. Resin particle size has a tremendous effect on sharpness of elution curves, the only limitation being a resin so fine that it cannot be properly used because of high pressure drop. Feed volume and concentration of course affect the degree of separation but also lead to other considerations. Elevated temperatures tend to improve separations and make possible more efficient use of the resin. Lower flow rates give better separations but must not be considered apart from resin efficiency.

It is difficult to establish a sharp line of demarcation between the ionic and nonionic solutes. This is a particular problem with the organic acids and bases. Materials having an ionization constant of less than 10^{-4} are definitely nonionic in behavior, above 10^{-1} definitely ionic. The intermediate area is a figurative no man's land and must be considered for each system.

COLUMN ANALYSIS

A more extensive study of some factors entering into ion exclusion and general ion exchange separation has been carried out by the mathematical analysis of single component elution curves (*9*). In this analytical method an attempt has been made to interpret the behavior of an ion exchange (or ion exclusion) column in terms similar to those familiar in studies of packed distillation columns, where the plate concept is applied. By the use of these methods and their application to ethylene glycol elution curves, the effect of resin and operating conditions may be studied.

The most important conclusions in the range of work investigated have determined that the height of a theoretical plate (H.E.T.P.) is directly proportional to the particle diameter and that H.E.T.P. is directly proportional to the square root of the flow rate of the solution. H.E.T.P. varies only slightly with resin crosslinkage (this study is based on ethylene glycol) and feed volume and is independent of column height.

The effect of particle size is particularly striking (Figure 5). Obviously the finer mesh resins are to be desired within the limits of practical operation. The number of plates possible in a normal 3 to 5-ft. deep resin bed is realized when the calculated plate height for the 200 to 400-mesh resin is under 0.05 in.

As further investigations were carried out with ion exclusion separations, it was realized that all nonionic materials did not behave alike—that under comparable operating conditions, feed volumes, concentrations, etc., the various solutes would appear in the column effluent at different times. This suggested that the nonionics were not equally distributed between the resin and outside solution phases as first generalized.

For example, with a moderately crosslinked sulfonic-type cation exchanger, it was not possible to obtain a practical separation of either sucrose or glucose from sodium chloride whereas components such as ethylene glycol or acetone could be separated from salt easily. It was then realized that it should be possible to separate nonionic components by the use of column techniques much like that of ion exclusion. An example of such a separation is shown in Figure 6 for the fractionation of d-glucose and methanol.

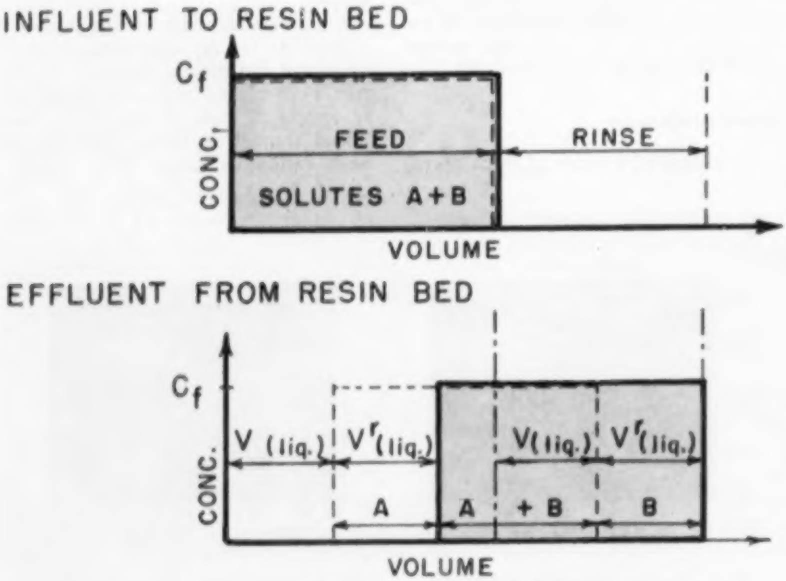

Fig. 3. Theoretical elution curves. Ion exclusion.

EQUILIBRIUM RELATION

It becomes obvious that to characterize the behavior of the various solutes it is necessary to determine the equilibrium relationship between inside and outside solution concentrations which has been defined:

$$K_D = \frac{C^r_{(liq)}}{C}$$

where K_D is the distribution constant and

$C^r_{(liq)}$ and C are solute concentrations in the inside and outside solution phases.

By this definition, salts would have a K_D value of about 0.1 at low and moderate concentrations and nonionics might vary all the way from near 0.1 to well above 1.0. For example, with a sulfonated cation exchanger in the H^+ form, sucrose has a K_D value of 0.24, glycerine 0.49, and acetone about 1.2. These values were determined at an initial outside concentration of 5% in batch equilibrium experiments. It is now believed that more accurate K_D values may be obtained by use of dynamic column operations and material balances.

On the assumption that operations are at equilibrium conditions, it is possible to determine when a given solute will appear in the effluent from a column. It has been shown in the case of the hypothetical, completely excluded ionic material that it will appear after the displacement of $V_{(liq)}$, the interstitial volume in the bed, whereas the idealized nonionic, where $K_D = 1$, will appear after $V_{(liq)} + V^r_{(liq)}$ volumes of liquid.

A general equation for the system, however, may be written thus:

$$V_e = V_{(liq)} + K_D V^r_{(liq)}$$

where V_e may be defined variously as the leading edge of an idealized square wave or the peak concentration of an infinitely small feed or, more practically, as the approximate midpoint of the leading edge of an elution curve.

The interstitial volume ($V^r_{(liq)}$) in a normally packed ion exchange bed is found to approximate closely $0.38V_t$ (V_t = bulk volume of resin bed). $V^r_{(liq)}$, depending on the resin and system considered, can vary tremendously. Functional group, capacity, ionic form, crosslinkage, and solution concentration all enter into this value. For Dowex 50–X8, H^+ form, the number approximates 0.40 V_t. This means that the solid resin portion is only 22% of the total bed volume in this example.

The maximum degree of separation possible between two components (A and B) would be

$$Ve_A - Ve_B = (K_{D_A} - K_{D_B}) V^r_{(liq)}$$

It is thus seen that if two solutes have K_D values differing by only 0.1, only

$$(0.1)(.40\ V_t) = .04\ V_t$$

or 4% of the bed volume may be fed per cycle and considerably less than this for complete separations in the practical situation. K_D values differing by 0.5 may, by the same token, permit feed volumes up to 20% of the bulk bed volume, a quite different situation from the commercial viewpoint.

The situations presented here have been somewhat oversimplified. Actually, studies of most solute distribution constants show nonlinear isotherms as determined directly or by observance of the elution curves. A symmetrical curve, such as is approached in the case of ethylene glycol, indicates little change of K_D with concentration, at least in the range studied. Solutes which are most strongly sorbed in the resin solution phase at high concentrations, such as ionic materials, give broad leading and sharp trailing edges. Those materials most strongly sorbed at low concentrations, notably the phenols, give the opposite picture.

An important factor affecting the nature of the elution curves, and extremely important in its consequences, is the variation of K_D for one component with the presence of a second component—particularly notable with nonionics in the presence of electrolytes. Thus with ethylene glycol the K_D value increases from about 0.5 to over 1.0 in the system Dowex 50–X8, Na^+—ethylene glycol—sodium chloride—water as the salt concentration is increased from 5 to 20%.

In the recycle method of ion exclusion (*10*), described later, a typical elution curve is shown in Figure 7 for the separation of a solution containing 20% sodium chloride and 10% ethylene glycol. This is after three cycles of operation and shows that the peak concentration of the glycol is nearly 2.4 times that of the feed. This may be explained by the sudden drop in K_D for the glycol as the salt is removed and, thus, a concentrating effect in the interstitial solution, reflected in the effluent, and a dilution within the bead.

How is this information on ion exclusion and nonionic-type separations relayed into a practical operating method? Several methods have been or are being considered. Each has its own merits and disadvantages.

It was obvious from the first that the most efficient operation could be realized if as little water as possible appeared between the ionic and nonionic fractions, and that a semicontinuous operation could be carried out by simply alternating feed and water in proper proportions, thus having several waves in a column at one time. Equipment controls were simple. A 30-cu.ft. bed was actually operated in this manner for several months.

RECYCLE METHOD

A newer method has been referred to as the *recycle method*. It is best described by referring to the diagram of Figure 8. In this an area of cross-contamination is purposely created to give the maximum resin efficiency and to eliminate product dilution. In this method a system is simulated in which the effluent stream is continuously recycled back through the resin bed. The size of the increments returned determines the closeness of approach. On the assumption that the nonionic component is the desired product in this sketch, it is possible to recover it at, or above,

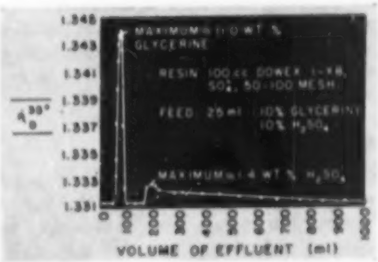

Fig. 1. Separation of glycerine and sulfuric acid on a resin sulfate.

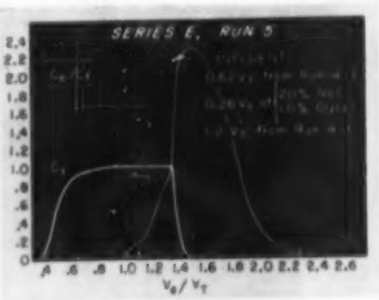

Fig. 7. Ion exclusion separation of sodium chloride and ethylene glycol. Recycle method.

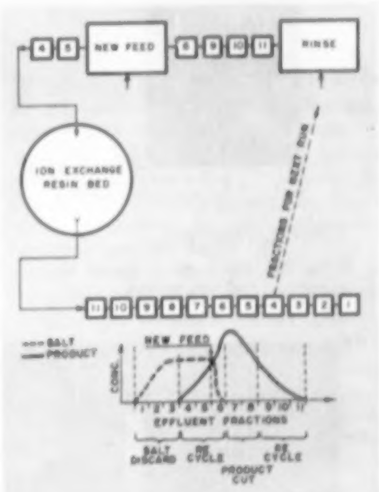

Fig. 8. Recycle method of ion exchange.

feed concentration at the same time discarding a dilute solution of the salt equal in weight to that in the feed. The chief drawback of this operating method on a commercial scale is the complexity resulting from the multitude of storage vessels and valves required. Perhaps a dynamic storage method may yet be developed.

BATCH RECYCLE METHOD

Many advantages of the method, however, can be realized through the use of one recycle storage tank, which may be used as a blending tank for the cross-contaminated effluent along with a new feed quantity (Figure 9). This is called the *batch-recycle method* and may with proper operation give product cuts at near feed concentration.

The most efficient method and equipment to be used for the countercurrent contacting of resin liquid is still being sought. Such a *continuous system* is sketched in Figure 10. Here the resin is flowing downward at constant linear velocity against an upflowing stream of solution. The column profile represents a steady-state condition resulting from proper balance of flow rates within the column and at feed and take-off points. The problems encountered here are of the same general type as discussed in connection with the continuous operations, though perhaps magnified in some respects.

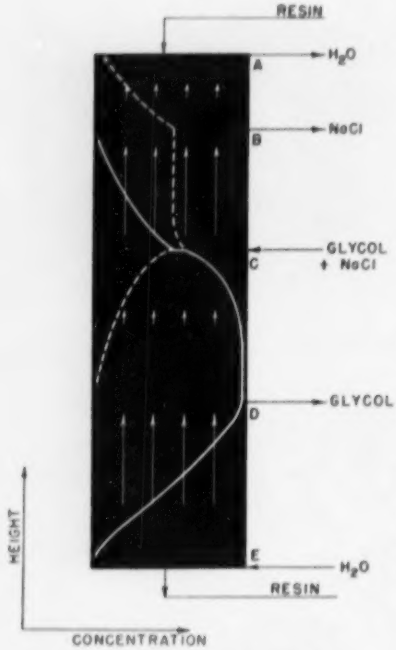

Fig. 10. Sketch of continuous ion exclusion method.

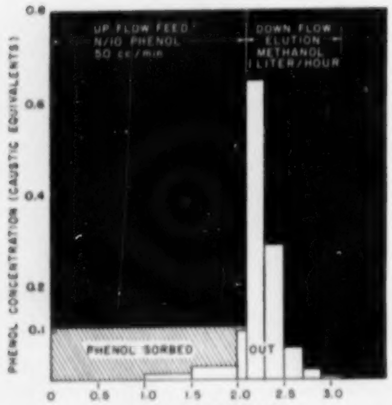

Fig. 11. Sorption of N/10 phenol on 255cc. of Dowex 1 Cl and elution with methanol.

This discussion has consistently emphasized the removal of ionic materials in the purification of nonionics; however, the converse also has practical applications, and it is believed that a pilot plant is now under construction for the purification of a salt. A 30-cu.ft. ion exclusion bed has been operated for over 1,800 cycles with great success, and more recently a 600-cu.ft. unit has been pressed into service—doing a job at a cost that could not be even closely approached by any competitive process.

Phenol Sorption

Although related to ion exclusion in the sense that it involves other than truly ion exchange properties of the ion exchange resins and also in that it may be considered a method for separating ionic and nonionic components, phenol sorption cannot properly be discussed along with ion exclusion. Certainly the mechanism is less clearly understood and normal ion exclusion techniques of elution become impractical.

The phenol sorption process (*11*) evolved from several sources. It applies to the various members of the phenol family though no all-inclusive operating procedure may be described.

The strongly basic anion exchange resins exhibit a strong affinity for the phenolics over and above the true ion exchange capacity of the resins, which make it possible in one example to remove 90% of the dilute trichlorophenol from a 15% sodium sulfate solution. This may be accomplished by starting with the resin in the sulfate form, to which form it would be rapidly converted in any case. Being a much stronger acid, sulfate would normally replace phenol on the resin, barring the additional sorptive effects.

In studies of ion exclusion and the determination of equilibrium solute distribution constants, a value of 17.7 was determined for phenol on Dowex 1, far out of line as compared to other solutes. It did not seem possible that this could be a true distribution constant; instead it was found to be more closely related to the non ion exchange capacity of the resin for phenol. As the concentration, and thus the absolute quantity, of phenol in the equilibrating solution was increased the apparent K_D value was found to decrease from 80.6 to 14.6 in going from 0.1 to 5.3% phenol.

A third indication of the strong sorptive effect of resins for phenolics is the tenacity with which indicator dyes may be held by the resins and used repeatedly, without apparent loss, to show *p*H change. Advantage is taken of this factor in some of the dyed mixed-resin units now on the market. An anion exchanger at high *p*H may be intensely red with phenolphthalein without the slightest indication of color in the effluent solution.

Whereas the phenols are strongly sorbed from aqueous solution, they have considerably different isotherms in organic solvents. Methanol has been found to be one of the best extractants. Figure 11 shows the sorption of phenol by the chloride salt of a quaternary ammonium anion exchange resin, followed by methanol elution. In this case of 19.5 g. phenol picked up by the resin 19.4 g. was removed with methanol without any chloride displacement from the resin during the cycle. The inlet feed concentration was rather high at 0.1 *N*; at lower feed concentration, more solution of course may be treated with a greater concentrating factor resulting from the methanol rinse. However, the absolute amount of phenol removal possible by the method decreases at lower concentrations as a result of early leakage.

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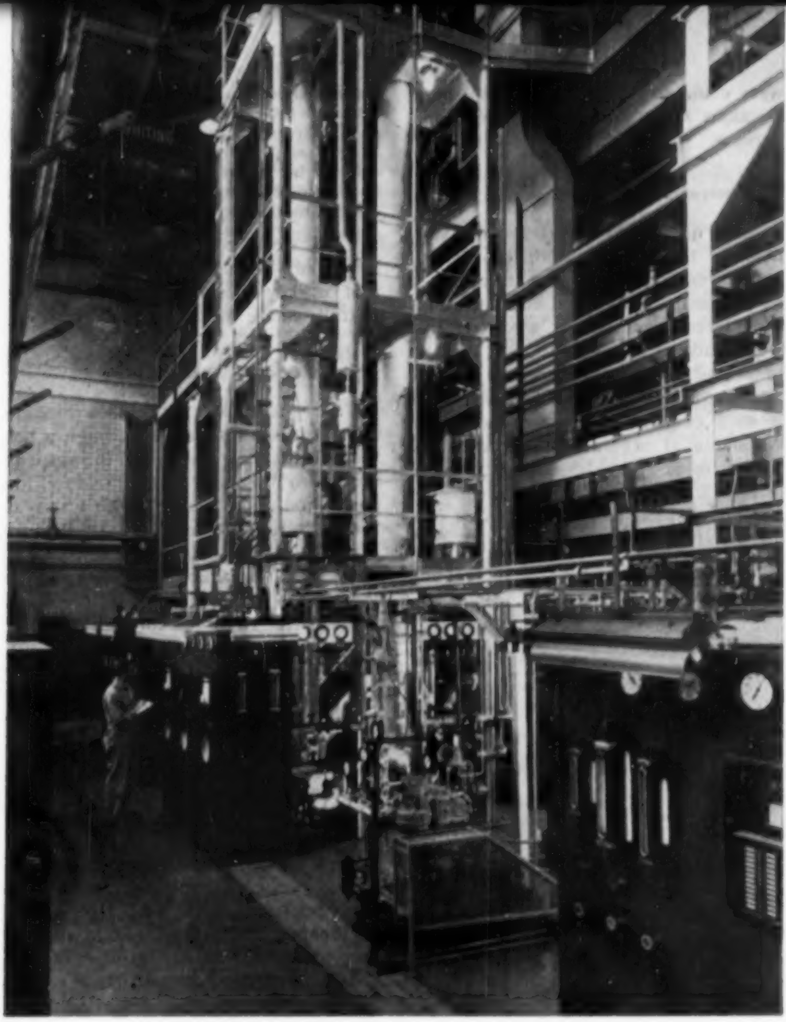

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improved process for CO$_2$ ABSORPTION uses hot carbonate solutions

An improved process has been developed for removing carbon dioxide from pressurized gases, such as gas mixtures for the ammonia and Fischer-Tropsch synthesis. A previous study of a process utilizing absorption with a hot solution of potassium carbonate indicated that a relatively small amount of steam was required for regeneration of the spent solution. In this paper the results of further investigation of the hot carbonate process in a pilot plant are given with emphasis placed upon the determination of the steam consumption for regeneration at many operating conditions. For purposes of comparison, results of similar tests are shown for solutions of monoethanolamine operated at conventional absorption conditions. Experiments were made with carbon dioxide-nitrogen mixtures in a 30-ft. high absorber and a 25-ft. high regenerator. It is believed that the data are applicable to large-scale installations.

Removal of carbon dioxide from gas mixtures is a necessary and expensive step in many industrial processes. It is of particular importance in the synthesis of liquid fuels from coal by the Fischer-Tropsch process in which about 10,000 cu.ft. CO_2 must be scrubbed per barrel of gasoline produced. In the synthesis of ammonia by reforming natural gas almost 20,000 cu. ft. CO_2 are removed per ton of ammonia.

Processes for scrubbing carbon dioxide may be divided into two classes: those based upon solubility such as water-scrubbing and the Rectisol process which uses methanol at low temperature *(2)*, and those depending upon chemical reactions with an alkaline medium, either inorganic, such as potassium carbonate, or organic, such as the ethanolamines. Water-scrubbing has been used widely in European synthetic fuels and ammonia plants and there are some installations of this type in this country for the purification of ammonia synthesis gas *(4)*. For this purpose, the process may be considered when the pressure is at least 200-300 lb./sq.in. and the carbon dioxide concentration in the gas is high. However, the capital

investment is considerably higher with water scrubbing. The carbon dioxide cannot be recovered since regeneration is done normally with air and, should any hydrogen sulfide be present, a pollution problem is created. In addition, losses of carbon monoxide and hydrogen by solution are costly in water scrubbing. Little information has been published about the Rectisol process which has been installed in a South African Fischer-Tropsch plant. With this plant now in operation, a better evaluation of the Rectisol process will be possible. Monoethanolamine is currently preferred in this country for removing carbon dioxide and has largely replaced sodium and potassium carbonate solutions formerly used for this purpose. However, the steam requirements of the process are considerable.

At the Bureau of Mines at Bruceton, Pennsylvania, where research is being conducted on the synthesis of liquid fuels from coal, a process has been developed for removing carbon dioxide by hot concentrated solutions of potassium carbonate. The chief objective is to reduce the cost of removal of carbon dioxide from synthesis gas. Essentially, this process involves absorption of carbon dioxide at elevated pressure at or near the temperature prevailing in the regenerator, followed by a pressure let-down and conventional steam stripping. With this mode of operation, the need for heating the liquid between the absorption and regeneration steps is avoided; thus both steam and heat-exchange equipment are saved. A further advantage of maintaining the solution at high temperature during absorption is the much higher solubility of relatively insoluble potassium bicarbonate, which increases the quantity of carbon dioxide that can be absorbed per gallon of solution.

Initial work in a small plant showed that less steam was required for regenerating the spent solution than with ethanolamine (*1*). However, because the towers for absorption and regeneration were much shorter than required for satisfactory purification of the gas, only a limited amount of information was obtained. Consequently, a pilot plant with taller towers was constructed. Results of operation of this plant with single and split streams of carbonate solution are given. A study of the process variables, such as carbon dioxide content of raw and scrubbed gases and carrying capacity of the liquid, was made to determine the minimum steam requirements for regenerating the spent solution for a given scrubbing operation. Equilibrium pressures of carbon dioxide and water vapor were measured over solutions equivalent to a 40% by weight solution of potassium carbonate with varying amounts of bicarbonate. Runs were made also with monoethanolamine solutions to establish a basis for comparison.

Equilibrium Data

Since no equilibrium data were available for the system carbon dioxide-potassium carbonate-potassium bicarbonate at the temperatures and concentrations of interest, equilibrium measurements were made in a steam-jacketed, rocking autoclave. Pressures of carbon dioxide and water vapor were determined over a 40% original solution of potassium carbonate at several concentrations of carbonate and bicarbonate. In Figures 1 and 2, the equilibrium pressures of carbon dioxide and water vapor are shown at four temperatures as a function of carbon dioxide in solution, a measure of the extent of conversion of carbonate to bicarbonate. As the liquid volume increases with progressive conversion to bicarbonate, the volume of the original 40% solution at 75° F. was used as a basis. The plotted carbon dioxide values are those for carbon dioxide as bicarbonate only; thus, zero on the abscissa represents the solution of 40% potassium carbonate without bicarbonate. Stoichiometrically, about 12 std.cu.ft. CO_2 (32° F., 1 atm. *p.*) can be absorbed/gallon of 40% solution for complete conversion to bicarbonate, but the practical limits of operation lie within the range of 2 to 9 cu.ft. as shown in the figures. The curves of Figure 2 are used for computing equilibrium pressures of water vapor above the solution.

Pilot Plant Operation

A. EQUIPMENT

A schematic diagram of the pilot plant is shown in Figure 3.

The absorber column consisted of a 6-in. schedule 80 pipe packed to a height of 30 ft. with ½-in. porcelain Raschig rings. The regenerator column was an 8-in. diam. schedule 40 pipe packed also with ½-in. porcelain Raschig rings to a height of 25 ft. All equipment was constructed of carbon steel with the exception of the circulating pump which was type 303 stainless steel, and the regenerator reflux condenser made of type 304 stainless steel.

Heat losses were minimized by insulating both columns with a 1-in. layer of preformed magnesia wound with ⅜-in. copper tubing for steam tracing and covered with an additional 1-in. layer of magnesia.

This method of insulation allowed only negligible heat losses from the columns. When the steam temperature was maintained close to the average temperature of the solution, the possibility of heat input to the system was minimized.

To compensate for heat losses in the piping and in the circulating pump, a heater was installed just ahead of the absorption column to reheat the solution to the temperature at which it left the bottom of the regenerator reboiler. A second heater was placed ahead of the regenerator column to reheat the carbonate solution to the temperature prevailing at the bottom of the absorber column.

Thus, steam consumption obtained in this study should be comparable with that in large-scale installations where heat losses are relatively small.

OPERATING PROCEDURE

Feed gas containing carbon dioxide and nitrogen was passed through a hot vessel containing water, and the gas was heated to the desired temperature for absorption and saturated with water at the pressure employed. This vessel could be by-passed so that the use of cold gas could also be studied. Gas leaving the top of the absorber was metered and vented after it passed through a cooler where water vapor was condensed.

The regenerated hot, concentrated solution of potassium carbonate-bicarbonate from the regenerator was pumped into the top of the absorber above the packing. A second feed point was located about 4 ft. below the top of the packing so that split-feed operation could be studied. In split-stream operation, a portion of the regenerated carbonate (usually one third) was cooled to a temperature about 35° F. below that of the regenerator and fed to the top entry, while the main stream was fed to the lower entry without cooling. To obtain better distribution of liquid, the top 5 ft. of ½-in. packing was removed and replaced with 3.8 ft. of ¼-in. packing.

The spent solution left the bottom of the absorber, passed through the preheater, where the temperature was adjusted to that of the bottom of the absorber, and through the pressure let-down valve. It could be sent then into the flash chamber where steam and carbon dioxide flashed from solution could be either collected and measured in the overhead condenser and metering system or fed into the column below the point of liquid entry. With this arrangement the stripping action of the steam-carbon dioxide mixture on the solution could be studied. Except for a few tests, the flash chamber was by-passed, however, and the solution with flashed gases was fed directly to the top of the regenerator.

The spent solution was passed downward through the regenerator where it was stripped by steam generated in the reboiler section at the bottom of the column. Steam for regeneration was fed into a coil of ½-in. standard carbon steel pipe. The quantity of steam was determined by collecting and measuring the condensate from the coil. Regenerated carbonate solution flowed from the re-

boiler to a duplex piston pump and then to the absorber.

Steam and stripped carbon dioxide left the top of the regenerator and flowed to the overhead reflux condenser. Steam condensate refluxed to the top of the regenerator column, and the carbon dioxide passed through a back-pressure regulator to the metering system. Part of the condensate could be withdrawn, when necessary, to adjust the concentration of the solution. Heat removal in the condenser was measured by metering the flow of condenser water and temperature increase. A heat balance was calculated for the heat present in the carbonate and steam feeds to the regenerator, that removed by the reflux condenser, and that required by the decomposition of potassium bicarbonate. An experiment was not considered valid unless the heats balanced within 10%. The regeneration efficiency (cubic feet of carbon dioxide per pound of steam required for regenerating the spent solution) was calculated from the steam input.

Before a run was started, the system was pressurized with nitrogen, and the pressure regulators on the absorber and regenerator were adjusted to the desired pressure. Meanwhile, the carbonate solution, which was kept in the regenerator reboiler and in the surge tank before the absorber, was heated by steam to the regeneration boiling point. While a small flow of nitrogen was maintained, the carbonate pump was started and the liquid rate established by setting the flow controller. Sufficient steam was sent to the tracing and preheaters to eliminate temperature gradients. Then the inert gas containing carbon dioxide was fed to the absorber at a controlled flow rate. To obtain the desired composition of scrubbed gas, the steam input to the regenerator coil was adjusted. The system was kept at steady conditions for several hours before sampling.

The flows of feed, scrubbed, and regenerated gas were measured by displacement meters and analyzed by Haldane or Orsat apparatus. Carbon dioxide analyses of the feed and scrubbed gases by absorption in caustic were recorded automatically every two minutes. The regenerated and spent carbonate solutions were analyzed for specific gravity, total equivalent potassium carbonate, and the volume of carbon dioxide evolved per volume of solution on acidification. From these analyses, simultaneous equations expressing weight balances of potassium carbonate were computed, and carbon dioxide combined as bicarbonate was determined. Concentrations were expressed as "per cent equivalent potassium carbonate" which represents the sum of potassium carbonate and the carbonate equivalent of potassium bicarbonate.

B. RESULTS

Monoethanolamine Scrubbing

To establish a basis of comparison, tests were made first with 15 and 30% monoethanolamine solutions as absorbent. The operating procedure was similar to that described for the carbonate solution except that conventional absorption temperatures were employed with the solution entering the top of the absorber at about 100° F. and leaving at a temperature some 40 to 70° F. higher because of the heat of reaction. The spent amine leaving the absorber was preheated to a temperature 40° F. below that of the reboiler before it was let down in pressure. This would then simulate the function of an amine heat exchanger where the spent amine would be heated to a temperature 40° F. below that of the boiling point of the regenerated amine.

Thus, the additional heat required to raise the temperature to the boiling point was obtained from the steam input to the reboiler. For these experiments the rate of inert gas flow covered a range of from 450 to 1,200 std. cu.ft./hr., and the amine flow was 10.3 to 106 gal./hr. Carbon dioxide concentrations in the feed gas of 10 and 20% were used at absorption pressures of 100 and 300

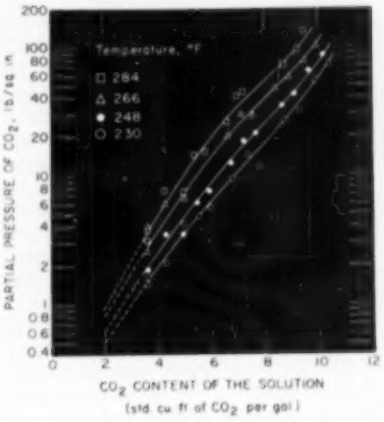


Fig. 1. Equilibrium pressures of CO_2 over K_2CO_3 solution (40% equivalent K_2CO_3).

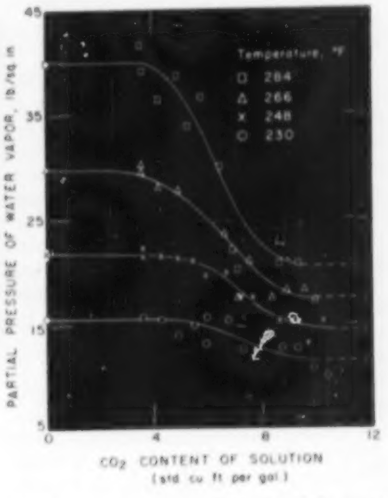


Fig. 2. Equilibrium pressures of H_2O vapor over K_2CO_3 solution (40% equivalent K_2CO_3).

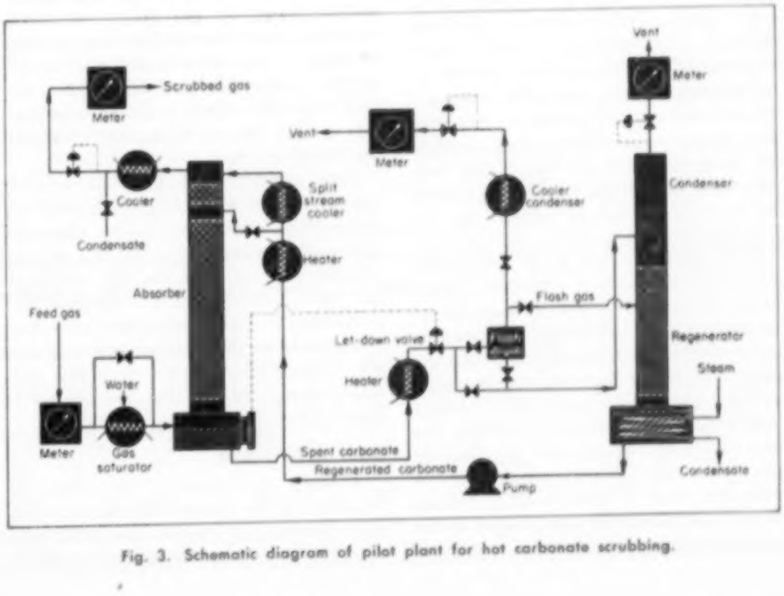


Fig. 3. Schematic diagram of pilot plant for hot carbonate scrubbing.

lb./sq.in. gauge. Regeneration of the spent solution was conducted at 10 lb./sq.in. gauge. For each liquid flow the regeneration efficiency was determined for at least three different carbon dioxide contents in the scrubbed gas within the range of 0.1 to 2.5%. The effect of varying the carbon dioxide carrying capacity upon the regeneration efficiency was studied with solutions containing 15 and 30% by weight of monoethanolamine.

Within the range of conditions employed, the regeneration efficiency seemed to be very little affected by any variations in operation except carbon dioxide carrying capacity of the solution. The carrying capacity of the solution is the quantity of carbon dioxide actually absorbed per gallon of solution circulated. Carrying capacities have been calculated from the carbon dioxide balances in the gas streams and the rate of flow of solution.

Figure 4 shows the variation of the regeneration efficiency as a function of the carbon dioxide carrying capacity for all tests made with solutions of monoethanolamine and also with a 40-percent potassium carbonate solution. For both the 15- and 30-percent amine concentrations, the variation is similar, and with a carbon dioxide carrying capacity less than 3.7 cu.ft./gal. the curves are identical. As the carrying capacity increased, the regeneration efficiency increased, reached a peak value where it leveled off, and then dropped sharply with further increase in the carbon dioxide carrying capacity. For the 15-percent solution of amine the regeneration efficiency rose from about 3.0 to a maximum of 4.5 std. cu.ft. CO_2/lb. of steam, whereas for the more concentrated solution the maximum value was about 5 std. cu.ft. CO_2/lb. of steam. The regeneration efficiency reached its peak at a much lower carbon dioxide carrying capacity with the more dilute solution because of its lower alkaline content.

The shape of the curves in Figure 4 can be explained as follows: to regenerate a spent amine solution, heat must be furnished for three purposes: (1) sensible heat to raise the solution to its boiling point, (2) heat to support the desorption reaction, and (3) heat to produce steam for stripping by boiling the solution. The heat of reaction is constant; but as the carbon dioxide carrying capacity is increased, the sensible heat requirement becomes lower and the amount of steam required for stripping becomes greater for each cubic foot of carbon dioxide absorbed. Initially, the sensible heat requirement is lowered more than the stripping steam load is increased; but as the residual carbon dioxide content of the regenerated amine becomes lower, stripping the carbon dioxide becomes increasingly more difficult and more steam is required.

Potassium Carbonate Scrubbing

About 150 tests were made with a hot solution of potassium carbonate as absorbent. Absorption pressures of 100, 300, and 400 lb./sq.in. gauge were used. Most of the experiments, however, were conducted at an absorption pressure of 300 lb./sq.in. gauge. Pressures of 300 to 450 lb./sq.in. gauge are commonly employed in synthesis operations and impure gas would be available at this pressure. Regeneration pressures of 2 to 10 lb./sq.in. gauge were employed, and use of the lower pressure was more favorable. Feed gases containing 10, 16, 20, and 30% CO_2 (the remainder nitrogen) were used; the feed gas flow generally was 1,200 std. cu.ft./hr. when the pressure in the absorber was 300 lb./sq.in. gauge. In most of the tests the feed gas was hot and saturated with water vapor at the temperature and pressure of the absorber. However, little difference was noted in the steam consumption when a cold feed gas was used. The concentration of carbon dioxide in the purified gas was varied from 0.5 to 6%. Since a residual carbon dioxide content of 2% has been found acceptable for the Fischer-Tropsch synthesis of liquid fuels, many tests were made at this concentration of carbon dioxide in the scrubbed gas.

A 40% equivalent concentration of potassium carbonate with 0.2 to 0.3% sodium dichromate was used in all tests. Some variation in the carbonate concentration occurred during operation because of condensation of water vapor in the feed gas. The chromate virtually eliminated corrosion as weighings of mild carbon-steel strips placed at several points in the system showed corrosion values of zero to a maximum of 0.0004 in./yr. Maximum corrosion occurred on strips located in the spent carbonate stream at the bottom of the absorber. Inspection of the steam coils (mild steel) in the regenerator reboiler showed no corrosion after three years of intermittent service (about 18 months of actual operating time).

Both single-stream and split-stream operation were used. Slightly higher regeneration efficiencies were obtained with split-stream flow when the carbon dioxide concentration in the scrubbed gas was about 2%. A considerable improvement in regeneration efficiency was obtained when the residual carbon dioxide concentration of the scrubbed gas was about 0.6% by the use of split-stream flow.

Study of Variables

A study was made of the effect of variation in the carbon dioxide carrying capacity upon the regeneration efficiency with the hot carbonate solution similar to that previously made with solutions of monoethanolamine. For purposes of comparison, the results for split-stream flow of carbonate are shown in Figure 4, together with those for the monoethanolamine. Considerably less steam was required with the carbonate solution. The tests with hot carbonate were made at an absorption pressure of 300 lb./sq.in. gauge with a feed gas containing 20% CO_2 and 80% N_2. Carbon dioxide carrying capacities were varied from about 3 to 4.5 std. cu.ft./gal., whereas the concentration of carbon dioxide in the scrubbed gas was reduced to 2%. As the carrying capacity was raised from 3 to 3.7 std. cu.ft./gal. the regeneration efficiency remained constant at 9.8 std. cu.ft./lb. steam.

A further increase in carrying capacity resulted in a sharp drop in regeneration efficiency, the value decreasing to 8.25 std. cu.ft./lb. steam at a carrying capacity of 4.5 cu.ft./gal. The regeneration efficiency was less sensitive to variation in carrying capacity when the residual concentration of carbon dioxide was 0.6% to 0.7%, and a higher carrying capacity was reached (4.3 std. cu.ft./gal.) before the regeneration efficiency started to decrease.

Steam consumption in the hot carbonate system is determined by the ratio of steam to carbon dioxide in the gas leaving the regenerator, there being no sensible heating and little steam requirement for the heat of reaction. Since this ratio in turn is dependent upon the amounts of carbon dioxide in the regenerated and spent solutions, the following explanation for the shape of the curves in Figure 4 appears valid:

When the carbon dioxide carrying capacity is low, the regeneration efficiency is controlled chiefly by the conditions at the top of the absorber, that is, the degree to which carbonate must be regenerated by stripping steam to reduce the equilibrium pressure of carbon dioxide in the solution to the required value. With increasing carrying capacity the limiting factor becomes the extent to which carbonate can be converted to bicarbonate at the bottom of the absorber, which is dependent upon the partial pressure of carbon dioxide in the feed gas and upon the rate of transfer.

Thus, to scrub the gas to the desired concentration of carbon dioxide, the amount of carbon dioxide in the solution entering the absorber must be reduced (by more thorough regeneration requiring additional steam) to a value less than that needed for the lower carbon dioxide carrying capacity.

The steam consumption in the hot carbonate system is related to the concentrations of carbon dioxide in the feed and scrubbed gases, and to absorption pressure. In Figure 5 the regeneration efficiency is plotted as a function of the partial pressure of carbon dioxide in the

feed gas with concentration of carbon dioxide in the scrubbed gas as a parameter. The pilot plant data shown in Figure 5 cover a range of absorption pressures of from 100 to 400 lb./sq.in. gauge and concentrations of carbon dioxide in the feed gas of from 10 to 30%. The regeneration pressure was 2 to 3 lb./sq.in. gauge. Split stream flow to the absorber was employed, and tests were made at the optimum carrying capacity. The curves for 2 and 0.6-0.7% concentrations of carbon dioxide in the scrubbed gas show a similar trend. The regeneration efficiency increases as the partial pressure of carbon dioxide in the feed gas is increased and then levels off.

Although the regeneration efficiency is actually a function of the liquid composition entering and leaving the regenerator, since these are related to the partial pressure in the gas, the latter was used as abscissa for convenience. From this curve the regeneration efficiency may be predicted for known gas compositions and absorption pressures.

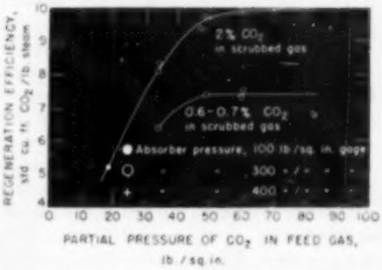


Fig. 5. Effect of partial pressure of CO_2 in feed gas on regeneration efficiency (split stream).

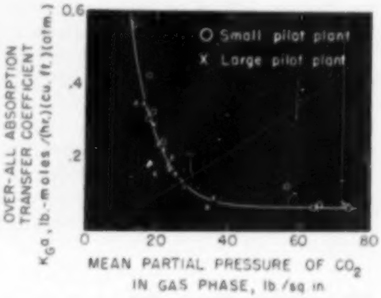


Fig. 6. Variation of K_Ga with the partial pressure of CO_2 in the gas phase (mass velocity of liquid: 3,000 to 3,700 lb./(hr.)(sq.ft.); temperature 255-275° F.).

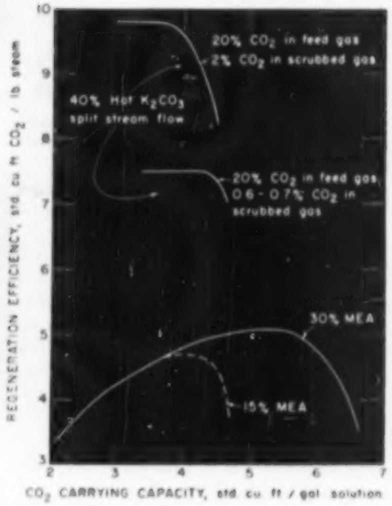


Fig. 4. Variation of regeneration efficiency with CO_2 carrying capacity.

Over-all Absorption Transfer Coefficients

In the paper on the results in the small plant (*1*), a curve was given showing the K_Ga values as a function of the mean partial pressure of carbon dioxide in the gas phase for a constant liquid mass velocity of 3,000 to 3,700 lb./(hr.)(sq.ft.). The same packing of ½-in. Raschig rings was used as in the present plant, but the packed height was only 9 ft. as compared with 30 ft. in the larger plant. Additional K_Ga values, obtained in the single-stream tests in the present study, are in good agreement with those of the earlier work (Figure 6). With the additional points, the shape of the curve can be determined more accurately.

Values of K_Ga are extremely sensitive to partial pressures of carbon dioxide up to about 25 lb./sq.in. and then become nearly constant. Evidently, the rate of reaction in the liquid is the limiting factor in this range, and K_Ga is insensitive to further increases in the driving force in the gas phase.

Applicability of Hot Carbonate System to Purifying Synthesis Gases

Hot carbonate scrubbing is applicable for the removal of carbon dioxide from raw synthesis gases when these gases are available or are used at elevated pressures and contain a sufficiently high content of carbon dioxide so that a high regeneration efficiency is obtainable. These conditions exist when coal is gasified with steam and oxygen under pressure to produce synthesis gas. Although most of the synthesis gas in this country has been produced by reforming natural gas at atmospheric pressure, recently the production of ammonia synthesis gases by the partial oxidation of natural gas, oil, or coal with commercially pure oxygen under pressures of 300 to 400 lb./sq.in. gauge has become promising (*3*). Plants using natural gas and oil as fuel are already in operation or under construction, and the possibility of coal as a fuel is being explored for another installation. After partial oxidation of these fuels and the shift reaction to convert carbon monoxide, the carbon dioxide content of the raw gas varies from 30 to 35%. The partial pressures of carbon dioxide are well within the more economical range for removal by the hot carbonate process.

Since fuels for gasification may contain sulfur, the simultaneous removal of hydrogen sulfide, which forms on partial oxidation, along with the carbon dioxide is of interest. A short series of tests with hot carbonate solutions have been made in the pilot plant with a feed gas at 300 lb./sq.in. gauge pressure containing 11% CO_2 and about 0.15 to 0.8% hydrogen sulfide. The carbon dioxide content of the scrubbed gas was lowered to 2 and 0.6%. Results of these tests given in Table 1 show that about the

Table 1.—Simultaneous Removal of Carbon Dioxide and Hydrogen Sulfide*

Run No.	Concentration in feed gas, % CO_2	Concentration in feed gas, % H_2S	Concentration in scrubbed gas, % CO_2	Concentration in scrubbed gas, % H_2S	Carrying capacity CO_2 cu.ft./gal.	Carrying capacity H_2S grains/gal.	% removal CO_2	% removal H_2S	Regeneration efficiency, cu.ft. CO_2+H_2S/lb. steam
64	11.7	0.84	2.2	0.063	3.1	131	90.1	92.9	8.8
64-A	11.9	.76	0.7	.027	3.1	121	94.8	96.9	5.9
64-B	11.5	.14	.6	.008	3.0	15.7	95.5	94.8	5.6

* Absorber pressure 300 lb./sq.in. gauge; gas flow 1,200 std. cu.ft./hr.; regenerator pressure 2 to 3 lb./sq.in. gauge; split-stream flow.

Table 3.—Estimated Costs of Removing 1,000 Cu. Ft. Carbon Dioxide from Synthesis Gas [a]

	Amine	Hot Carbonate
Steam ($0.40/1,000 lb.)	$0.10	$0.04
Equipment (20%/yr.)	.07	.05
Cooling Water ($0.01/1,000 gal.)	.02	.01
Total	$0.19	$0.10

[a] Absorption pressure, 300 lb./sq.in. gauge. CO_2 content feed gas, 20 vol. %. CO_2 content scrubbed gas, 2 vol. %.

same total fraction of each acid gas was removed in the absorber. The regeneration efficiency was the same as when no hydrogen sulfide was present. In a few tests 10 to 40 gr. of carbonyl sulfide, which usually is present in gases prepared by partial oxidation, was added/100 cu.ft. of the feed gas. Almost complete removal (to a few parts per million) was obtained because carbonyl sulfide is hydrolyzed to carbon dioxide and hydrogen sulfide by the hot carbonate solution. Further investigation of the purification of gases containing hydrogen sulfide and carbonyl sulfide is continuing as it is probable that by additional variations the sulfur content can be further reduced.

Optimum Operating Conditions

A summary of the optimum values of carbon dioxide carrying capacity and regeneration efficiency obtained in the pilot plant is given in Table 2. Values are shown for absorption at 300 lb./sq.in. gauge and regeneration at 2 to 4 lb./sq.in. gauge with concentrations of 10, 16, and 20% CO_2 in the feed gas, and 0.6, 0.8, and 2% in the scrubbed gas.

For many applications, the desired content of carbon dioxide in the scrubbed gas can be somewhat lower (0.1 to 0.2%) than the values shown in the data. This degree of purification can be achieved economically in the hot carbonate system by use of split-stream flow in the regenerator, as well as in the absorber. The total stream of spent carbonate is sent to the top of the regenerator after pressure let-down. The main stream is withdrawn after passing through the upper section of the tower and returned to the lower section of the absorber. The smaller stream flows to the bottom section of the regenerator, where it is thoroughly regenerated by the total steam supplied to the reboiler and is returned to the top of the absorber. Although the effect of all operating variables on this modification was not studied, a steam regeneration efficiency of 7 to 8 cu.ft./lb. steam was obtained when the feed gas contained 30% CO_2 and the pressure was 300 lb./sq.in.

Advantageous Use of Hot Carbonate Process

The economic advantage of the hot carbonate process under favorable conditions can be estimated by considering removal of carbon dioxide from a raw synthesis gas with 20% CO_2 at 300 lb./sq.in. gauge. If the concentration of carbon dioxide is to be reduced to 2%, based on the pilot plant results, a regeneration efficiency of 9.8 cu.ft. CO_2/lb. steam can be obtained with split-stream flow. Conventional plants using amine solution (probably the most favorable competitive process) at the same conditions generally obtain a regeneration efficiency of about 4 cu.ft./lb. steam. At a steam price of $0.40/1,000 lb., steam costs for regeneration are $0.041 and $0.10/1,000 cu.ft. CO_2 for the hot carbonate and amine systems, respectively. The value of steam varies at each plant and any change naturally will alter these figures.

Estimated Cost of Systems

Other savings possible with the hot carbonate compared to an amine system are a reduction in the plant investment of about one third by the elimination of heat exchangers, heaters and coolers, and by a decrease in the cooling water requirements. A comparison of the estimated costs for the two systems is shown in Table 3; the total cost for scrubbing 1,000 cu.ft. CO_2 is $0.19 for the amine and $0.10 for hot carbonate scrubbing. Fixed and operating charges for plant investment were estimated at 20% of plant cost per year. Pumping costs were assumed to be about the same for each process, and losses of absorbent were not included. Carbonate replacement costs would be lower because of the cheapness and nonvolatility of the absorbent. Since the cost of removal of carbon dioxide by monoethanolamine has been estimated to be about $0.04/gal. synthetic gasoline produced from coal, a significant reduction in the cost of synthetic fuels would be achieved by the use of the hot carbonate system.

Selection of the most economical purification process for the removal of carbon dioxide depends upon many factors, and can be decided only after a thorough study and cost estimate. At absorption pressures below 100 lb./sq.in. gauge, use of monoethanolamine is favored; at higher pressures the economics of the hot-carbonate and water-scrubbing processes become more favorable. Each process has certain advantages and disadvantages that must be evaluated. The quantity of gas to be treated, the gas pressure, the concentration of carbon dioxide, and the degree of purification required are of importance; availability and cost of utilities may be the deciding factor; the presence of other impurities in the gas may influence the selection of processes; and the integration of the purification step into the over-all plant scheme must be considered. The addition of the hot carbonate process to those already in usage offers the design engineer a further choice of purification processes.

Table 2.—Optimum Operating Conditions

(300 lb./sq.in. absorber pressure)

CO_2 content, %		Single stream		Split stream	
Feed gas	Scrubbed gas	CO_2 carrying capacity, cu.ft./gal.	Regeneration efficiency, cu.ft. CO_2/lb. steam	CO_2 carrying capacity, cu.ft./gal.	Regeneration efficiency, cu.ft. CO_2/lb. steam
20	2	3.8	9.4	3.8	9.8
20	0.8	4.5	6.8	4.0	7.8
20	0.6	...	...	4.2	7.5
16	2	3.7	8.5	3.4	9.8
16	0.8	3.7	6.05	3.8	7.7
16	0.6	...	...	3.9	7.3
10	2	...	...	3.1	8.3
10	0.6	...	...	3.1	6.0

Literature Cited

1. Benson, H. E., J. H. Field, and R. M. Jimeson, Chem. Eng. Progr. **50**, 356 (1954).
2. Vidt, E. J., and D. W. Beery, "Comparison of Carbon Dioxide Removal Processes," Presented at Am. Chem. Soc. meeting, Kansas City, Mo. (April 30, 1954).
3. Weber, George, Oil Gas J., **54**, No. 20, 80-83 (September 19, 1955).
4. Yeandle, W. W., and G. F. Klein. Chem. Eng. Progr., **48**, 349 (1952).

From the steps of the Boston Public Library, the visitor may look across historic Copley Square, at the heart of Boston's Back Bay, to famed Trinity Church and the new John Hancock Mutual Life building beyond.

BOSTON PROGRAM

— sessions for everyone

Ichthyologist* * sponsorship guarantees a meeting so varied that a dull moment will be impossible.

Big, comprehensive technical program at A.I.Ch.E. Annual Meeting in Boston, December 9-12.

H. G. Taylor and G. F. Eline, Jr.

Esso Standard Oil Co.

Quick checklist of sessions:

- **Explosions in oxygen producing plants—A comprehensive paper on role of contaminants, plus safe design and operation. Discussion invited.**
- **Low-temperature processing — Practical design and operation.**
- **Sales Engineer—Why be one, how to train, rewards.**
- **Nuclear Training Aids—For universities.**
- **Automatic control of processes—Round table of pioneers and you (bring slides).**
- **Want to own your own business?—What it takes.**
- **Pulp and Paper—Mushrooming field for the chemical engineer.**
- **Getting business in nuclear field.**
- **Fundamentals — One-third of meeting papers on filtration, distillation, etc.**

* Ichthyologist: a fish lover! Or, to chemical engineers, the Boston Section of A.I.Ch.E., which has a by-law: "The order of business shall be varied so as not to get monotonous."

The chemical engineer descending from his plane at famed Logan International Airport nestled in quaint old Boston Harbor, where aqua saline, the life-giving fluid of the Ichthyologists all but laps at the wheels of the plane and symbolizes his arrival in the realm of the Kingfish and the Shark, will be stepping into a social whirl and a technical and "career-building" program that should produce enough notes to keep his secretary busy until the next A.I.Ch.E. meeting.

Sunday, as the shades of night fall over the ancient city, the lamps of Ye Olde Statler hostel will start to glow their welcome at the traditional get-together party where the engineer will meet a lot of other engineers and say hello to his old friends. Engineers have been known to travel across the continent just for this opportunity to contact other engineers.

Boston is an Annual Meeting and activity will be rampant, with committees at work behind *open* doors, awards being readied for the outstanding fortunates to be honored at the annual banquet, speeches being prepared for luncheons and banquets, and, of course, Council in action.

There will be sessions of interest to everyone, and sessions of special interest to particular groups, and sessions that are both.

Explosions and Low-Temperature

Do you, for example, have an interest in explosion hazards in oxygen production plants?

A special Wednesday afternoon paper by Kerry, followed by discussion by interested parties, will deal with the identification and role of contaminants and their control.

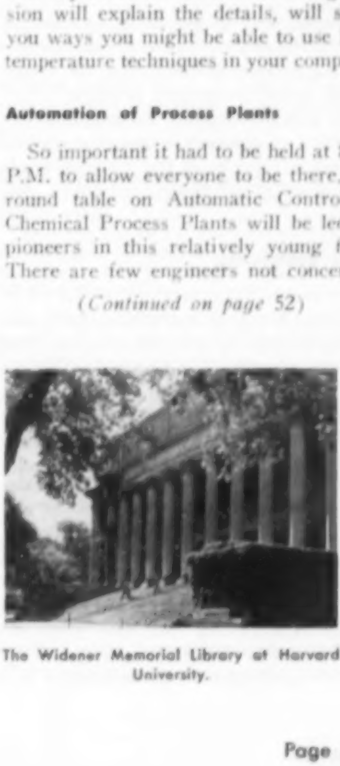
The rapid and continuing rise of low temperature processing since World War II has made this a major new field for the chemical engineer.

The Wednesday morning symposium will take up the basic processes, the broad, comprehensive picture of low-temperature. Primarily intended for the non-expert in the field, the morning session will explain the details, will show you ways you might be able to use low-temperature techniques in your company.

Automation of Process Plants

So important it had to be held at 8:00 P.M. to allow everyone to be there, the round table on Automatic Control of Chemical Process Plants will be led by pioneers in this relatively young field. There are few engineers not concerned

(Continued on page 52)



The Widener Memorial Library at Harvard University.

This panoramic water color of Boston (as seen from the observation deck of the John Hancock building) is by artist C. Robert Perrin. Reproduced through courtesy of *Ford Times*.

BOSTON MEETING PROGRAM . . .

(*Continued from page* 51a)

with automation these days, so bring your own slides to this session, or just pencil and paper. There will be a special projector and three microphones and everyone's thoughts and ideas are needed.

Emphasis is going to be on the use of dynamic analysis of the chemical engineering process in contrast to the traditional equilibrium-state analysis. Progress and problems of the practical application of dynamic techniques will be discussed, the role of the chemical engineer in automatic process control emphasized.

Sales Engineering

An increasing percentage of A.I.Ch.E. members are directly engaged in the sale of equipment and services ranging from gaskets to complete processing plants, and there is something in this major three-part symposium for every engineer concerned with any aspect of sales engineering.

Thinking of trying your hand at sales engineering? The morning session will tell you just what sales engineering is, and the two afternoon sessions will tell you how you can train, how your work will be judged, and what you can expect as a reward.

The purchasing agent's view will be covered; theory as well as practice will be analyzed; the role, importance, and accomplishments of the sales engineer will be studied. For management men, the afternoon sessions will give what is essentially a practical handbook on how to hire, train, develop, use, evaluate and compensate the sales engineer.

Pulp and Paper—Calling Chemical Engineers

Not only is pulp and paper the fifth largest industry in the nation, the third fastest growing, and a major consumer of chemicals, but in a fully integrated mill a great many of the unit operations of chemical engineering are involved.

The industry is now in the process of transition from an art to a science, and the chemical engineer is being called upon to do the job. And not in cellulose production alone, but in the making of such products as vanillin, tall oil, drilling mud additives, adhesives and tanning agents.

SUNDAY, DECEMBER 9

SO YOU WANT TO OWN YOUR OWN BUSINESS?—A PANEL DISCUSSION. Robt. Siegfried, Badger Mfg., Cambridge, Mass., chairman. **Moderator:** C. L. Knowles, Knowles Assoc. **Panelists:** W. L. Abromowitz, vice-president, Chemical Division, The Borden Co.; W. I. Burt, president, Goodrich-Gulf Chemical; G. F. Doriot, president, American Research & Development Corp.; G. G. Brown, dean, College of Engineering, Univ. of Mich.

The panel will discuss, among other things, what individual traits cause some people to strike out on their own, while others stay with established corporations.

MONDAY, DECEMBER 10

AFTERNOON AT THE ICHTHYOLOGISTS (Boston Section), G. P. Taggart and F. G. Perry, Jr., presiding.

Session to be provided by the unique Boston Section (known as the Ichthyologists) to combine information of importance with an entertaining afternoon. Three papers will be presented:

How To Be Human On the Job, W. G. Strathern, Eastern Gas & Fuel Associates, Boston, Mass.

Modern Methods of Crime Detection, Capt. F. Wilson and Chief Chemist F. Stratton, Boston Police Dept.

One further subject and speaker to be announced.

GENERAL PAPERS—I, C. P. Baker, Northeastern Univ., presiding. (Simultaneous with Ichthyologists session)

Catalyzed Gas-Liquid Reactions in Trickling Bed Reactors, R. B. Babcock, G. T. Mejdell and O. A. Hougen, Univ. of Wisconsin, Madison, Wisc.

Kinetic studies made in a differential flow reactor on the hydrogenation of alphamethylstyrene with the liquid trickling over a bed of catalyst pellets counter-current to a stream of hydrogen.

Transient Behavior of a Packed Liquid-Liquid Extraction Tower, E. A. Lavergne and A. I. Johnson, Univ. of Toronto, Toronto, Canada.

An investigation of transient behavior and holdup for three systems made in a 4-inch I. D. packed liquid-liquid extraction column which points out some of the difficulties inherent in the mathematical analysis of transient operations, and which obtained results considered to be more representative of true tran-

The symposium will cover many phases of the industry with particular reference to its future, and the training of chemical engineers for the field.

Filtration—Major Changes

Developments have come fast in filtration. Material disclosed at this session will be of immediate practical importance to industry all over the country, including a basic, fundamental change in the theory of filtration presented by Scheidegger.

LADIES' PROGRAM

Sunday, December 9	
Get Acquainted Party	8:00 P.M.
Monday, December 10	
Coffee, Ladies Headquarters	9:00 A.M.
Fashion Lecture, Afternoon Tea	3:00 P.M.
Tuesday, December 11	
Coffee	9:00 A.M.
Bus Tour, Boston & Cambridge	10:00 A.M.
Banquet	7:00 P.M.
Informal Dance	10:00 P.M.
Wednesday, December 12	
Coffee	9:00 A.M.

A new, practical, direct technique for measuring filtration, long lacking in the basic literature, will be offered by Hutto, and Tiller is challenging the entire basis of present literature on the grounds that it is based almost entirely on constant pressure filtration—a condition that Tiller insists hardly ever exists in practice. Tiller is going to lay down a basis for calculating on variable rate-variable pressure filtration, which, he says, is the way we really filter in practice.

Do You Know How to Run a Business?

What do you really know about how businesses are run? A panel of experts on Sunday afternoon will discuss the subject "getting into business for yourself"—covering pros and cons, of course. Regardless of whether you are interested in becoming another J. C. Penny, or prefer—as most do—to have a role of importance on bigger team projects than one-man firms can handle, there'll be a

(Continued on page 54)

sient behavior than those of a similar study made by Huang.

Radioisotope Tracer Technique for the Determination of Holdup and Flow Characteristics in Packed, Countercurrent Liquid-Liquid Extraction Columns, R. B. Beckmann and S. E. Markas, Carnegie Tech, Pittsburgh, Pa.

This study reveals that "holdup" experiences an hysteresis cycle with variations of the continuous phase flow rate, and correlating equations are presented for "total" and permanent holdup below loading to account for this hysteresis.

Mass Transfer at Low Pressures, T. K. Sherwood and N. E. Cooke, MIT, Cambridge, Mass.

The evaporation of spheres of naphthalene into air, helium, carbon dioxide, and Freon-12, and of liquid diethyl adipate into air results in well-correlated data which lends semi-quantitative support to the theory of sublimation of crystals developed by Stranski.

A Cascade Impactor for Adiabatic Measurements, J. A. Brink, Jr., Monsanto Chemical, Research Dept., Everett, Mass.

Development of a small, compact "in-line" cascade impactor and accessory equipment for adiabatic particle-size determinations on saturated gases.

ADVANCING THE AUTOMATIC CONTROL OF CHEMICAL PROCESS PLANTS—A C.E.P. ROUND TABLE DISCUSSION (8:00 P.M.), W. D. Alexander and D. M. Boyd, presiding. Panel members are: P. S. Buckley, Du Pont; J. Draffen, Monsanto; E. G. Holzmann, Shell Development; A. R. Aikman, Schlumberger Well Surveying Corp.; and F. Woods, Carbide & Carbon Chemical.

Discussion will include how process control systems are engineered at present, how quantitative design methods have been developed and applied, the problems of trouble shooting in existing plants, design improvement, the ultimate goal of complete system design of entire plants, and what A.I.Ch.E. and the chemical engineering profession should do in this field.

TUESDAY, DECEMBER 11

THE SALES ENGINEER IN CHEMICAL ENGINEERING, PART I: DEFINING THE SALES ENGINEER, E. D. Kane, chairman. W. S. Berg, Arthur D. Little, Inc., Cambridge, Mass., presiding.

The Sales Engineer Defined, Stuart Edgerly, Fenwal, Inc., Ashland, Mass.

The function, importance, and contribution of the job called "sales engineer" and a description of the man who fills it.

Why They Buy, W. Alec Jordan, Chemical Data Co., New York.

The problem of fundamental rather than "applicational" research in the field of sales engineering. Also recent advances in the more "applicational" side.

Recruiting Sales Engineers, H. E. Beane, The Bristol Co., Waterbury, Conn.

A sales engineer must combine the knowledge and qualities of both an engineer and a salesman. Finding men with this combination is the number one problem of sales executives today.

GENERAL PAPERS—II, H. C. Weber, MIT, Cambridge, Mass., presiding.

A Proposed Correlation for Two Phase Flow Pressure Drop in Packed Columns, S. Subhan, J. J. McKetta, Jr., Univ. of Texas, Austin, Tex., and D. Cornell, Monsanto Chemical, Dayton, O.

The need exists for a general procedure for predicting the pressure drop for two-phase gas-liquid flow through packed columns. Through correlation of experimental data, such a procedure is developed in this paper.

Two Phase Pressure Drops in Large Diameter Pipes, R. C. Reid, A. B. Reynolds, D. H. Klipstein, A. J. Diglio, and I. Spiewak, MIT Engineering Practice School, Oak Ridge, Tenn.

Experiments show that while pressure-drop data in 4-in. pipes falls on the Lockhart-Martinelli curve, that for 6-in. pipes falls smoothly parallel 20% below, and there is indication that data for larger pipes would correlate on an even lower curve.

Rates of Flow Through Microporous Solids, E. R. Gilliland, R. F. Baddour, and J. L. Russell, MIT, Cambridge, Mass.

An investigation into the main variables affecting transport in absorbed layers which attempts to develop a better quantitative and qualitative understanding of the nature of such flow.

GENERAL PAPERS—III, K. C. Bell, A. C. Lawrence Leather Co., Peabody, Mass., presiding. (Simultaneous with symposia on Sales Engineering and General Papers—II)

Brazil's Petroleum Refining Industry, F. C. Williams and A. S. Moggi, Petrobras, Rio de Janeiro, Brazil.

The rapid growth and the methods of training engineers of Brazilian refineries, and the formation and scope of the new Brazilian Petroleum Institute.

Getting Business in the Nuclear Engineering Field, J. W. Blanton, National Research Corp., Cambridge, Mass.

Where, when and how can a specific company get business in the nuclear energy field? A review of National Research Corp.'s entry into zirconium production is used as a base.

Organic Coolant-Moderators for Nuclear Reactors, M. McEwen, Monsanto Chemical.

Under contract with BuShips, Dept. of the Navy, biphenyl; the tertiary eutectic mixture of biphenyl, m-terphenyl, and o-terphenyl; HB-40; and monoisopropylbiphenyl were studied to determine their feasibility as nuclear reactor organic coolant moderators.

THE SALES ENGINEER IN CHEMICAL ENGINEERING, PART II—TRAINING THE CHEMICAL

(Continued on page 54)

liberal education in this session, as to business operations, for you.

Nuclear Business and Variety

No company or engineer with any interest in the nuclear energy field can afford to overlook a paper which will give the "how" and "where" and "when" of getting nuclear business right now. It's in a General Papers session, is right from the horse's mouth because it's based on the decisions, problems and actions that went into National Research Corp.'s entry into the field with its new zirconium plant.

Variety is the key word for the six General Papers sessions. With Suez and oil in the news there is going to be a lot of attention paid to the paper discussing the rapid growth of Brazil's refineries.

PLANT TRIPS

Monday, December 10

MIT	2:00 P.M.
Monsanto Chemical	1:30 P.M.
Quartermaster R'sch & Devel.	1:30 P.M.
The Foxboro Co.	1:30 P.M.
Gillette Safety Razor Co.	1:30 P.M.

Tuesday, December 11

Carling Brewing Co.	1:30 P.M.
Champion-International Co.	1:30 P.M.
Arthur D. Little	2:00 P.M.
Sylvania Electric	1:30 P.M.
Walter Baker Division, General Foods Corp.	1:30 P.M.

University Nuclear Lab Facilities

AEC has announced its $3 million program of aiding colleges by financing facilities for teaching nuclear subjects. But what equipment? Educators can be helped by coming to the Boston symposium which will present detailed information on present laboratory equipment. It is aimed primarily at schools which do not have facilities at present—costs are included.

Mysterious Boston

Want to meet a Kingfish, a Mackerel, a Smelt and a Shark? You will—at An Afternoon With The Ichthyologists.

You can expect almost anything at this interesting, informative and light-hearted session. Two talks are scheduled—on How To Be Human on the Job, and Modern Methods of Crime Detection—but, as usual, the "fish lovers" have something up their sleeves—a mystery talk. Only two "fish" know what it will be or who will give it. Even *CEP* doesn't know, but we'll be there to find out!

SALES ENGINEER, W. E. Hesler, chairman. L. C. Johnston, Brown Fintube Co., New York, presiding.

Business Education for Engineers, E. P. Brooks, MIT, Cambridge, Mass.

The engineer of the future will be expected to know something of marketing, finance, accounting and control (including data processing), and particularly something about the human side of management.

Why Train? G. E. Seavoy, Whiting Corp., Harvey, Ill.

Business and merchandising are no longer arts—they are sciences. Good salesmen are not born, they are made, and what makes them is years of experience and training.

Experience is the Price of Success, P. J. Kelly, Calvert Distillers Co., New York.

There is only one way to learn about selling and that is by selling.

Training Chemical Engineers as Product Salesmen, J. J. O'Connell, Shell Chemical Co., New York.

The chemical sales engineer must have training in: 1) technical knowledge; 2) company policy and attitudes; 3) company products; 4) knowledge of consuming industries, their applications, processes and buying habits; 5) sales techniques.

PART III—PERFORMANCE AND COMPENSATION OF SALES ENGINEERS, W. E. Hesler, chairman, J. J. Costigan, The Sharples Corp., New York, presiding.

Performance Yardstick, Chemical Sales Engineers, Applied to Engineering and Construction of Chemical Plants, J. W. Ogden, Foster-Wheeler Corp., New York.

The salesmen of the engineering and construction of chemical plants cannot be judged on his volume of personal sales, it is a team operation. Some of the factors to be considered in measuring such a salesman's ability.

Holding and Rewarding the Sales Engineer, T. B. Ford, Dorr-Oliver, Inc., Stamford, Conn.

The positive use of the intangible as well as the tangible in the management of a sales engineering staff, as well as the problems of growth and progress of salesmen.

Measuring Effectiveness, H. O. Ehrisman, The Foxboro Co., Foxboro, Mass.

Because selling is inherently non-predictable, measuring a man's sales effectiveness involves many factors besides arithmetic analysis of sales volume.

How to Sell—A Purchasing Agent's View, T. E. Stevens, Du Pont, Wilmington, Del.

The personal habits, attributes, and acquired talents of the good sales engineer seen through the purchasing agent's eyes.

FILTRATION, F. M. Tiller, University of Houston, Houston, Texas, presiding.

Statistical Theory of Flow Through Porous Media, A. E. Scheidegger, Dept. of Mines and Technical Surveys, Ottawa, Can.

A simplified model of porous media is proposed which is basically the exact opposite of capillaric models. The porous media is assumed as fundamentally disordered, statistical mechanics is used to describe it, and the final result is a differential equation for the flow.

Distribution of Porosity in Filter Cakes, F. Hutto, Johns-Manville Research Center, Manville, N. J.

Work done to obtain unequivocal information on the distribution of porosity in filter cakes by means of direct measurement rather than by the usual indirect means.

Prediction of Cake Washing Results With Continuous Filtration Equipment, A. P. R. Choudbury and D. A. Dahlstrom, The Eimco Corp., Chicago, Ill.

It is essential in process industries which depend upon continuous filtration with cake washing to be able to predict soluble recoveries or removal as a function of operating variables prior to design of the plant.

The Role of Porosity in Filtration III, Variable Pressure-Variable Rate Filtration, F. M. Tiller, Univ. of Houston, Houston, Tex.

The industrially important and more general problem of variable rate-variable pressure filtration has received no attention in filtration literature, despite the fact that, as a practical matter, it is easier to perform than filtration under either constant pressure or constant rate.

Automation of Filter Equipment, J. F. Zievers, Industrial Filter and Pump Mfg. Co., Chicago, Ill.

Conditions, costs, and engineering aspects of automation in filtration equipment are discussed. Also the problem of training personnel.

GENERAL PAPERS—IV, M. H. Hutchinson, Stone & Webster Eng'g. Corp., presiding.

The Effect of Liquid Mixing on the Performance of Bubble Trays, A. S. Foss, J. A. Gerster, and R. L. Pigford, Univ. of Delaware, Newark, Del.

The efficiency of bubble trays is greatly affected by the gradient in liquid concentration in the direction of liquid travel, and one of the factors affecting this gradient is the rate of longitudinal liquid mixing.

Design of Perforated Plate Fractionating Towers, G. A. Hughmark and H. E. O'Connell, Ethyl Corp., Baton Rouge, La.

This paper extends the recent work that has revived interest in the use of perforated plate fractionating towers, and a design method is proposed which should permit the engineer to design these towers with the same confidence he has with bubble cap towers.

Ripple Trays—A New Tool for Vapor-Liquid Contacting, M. H. Hutchinson and R. F. Baddour, Stone & Webster Eng'g. Corp., Boston, Mass.

Data is presented for studies on the new vapor-liquid contacting tool—ripple trays. Offering many advantages, among which is the economy made possible by high capacity and simple construction, the ripple trays have high use potential for any two-phase contacting operation.

Effect of Operating Variables upon Tray Efficiency, J. A. Gerster, N. N. Hochgraf, A. G. Laverty, L. E. Scriven, and F. W. Wallis, Univ. of Delaware, Newark, Del.

The effects of gas rate, liquid rate, outlet weir height, and column pressure upon efficiency have been determined in 2-ft. diameter columns for three systems as part of the Plate Efficiency Research Program sponsored by the Research Committee of the A.I.Ch.E.

A Rigorous Graphical Method for Calculating Multicomponent Distillations, R. J. Hengstebeck and D. W. Schubert, Research Dept., Standard Oil Company (Indiana), Whiting, Ind.

Development of a method for determining reflux and tray requirements in multicomponent distillations by reducing the multicomponent system to equivalent binaries.

WEDNESDAY, DECEMBER 12

LOW TEMPERATURE TECHNIQUES, C. McKinley, Air Products, Inc., Allentown, Pa.

(*Continued on page 56*)

Turbo-Topics

TURBO-MIXER GENERAL AMERICAN TRADE MARK

TURBO-MIXER, a division of

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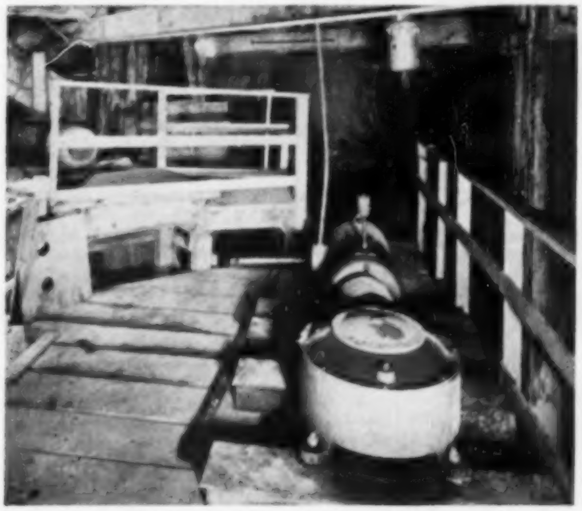

Leach Tank Agitators at Vitro Uranium Division of Vitro Corporation, Salt Lake City, Utah.

27" Turbo—Flotation Machines on potash at the Carlsbad plant of the Potash Division, International Minerals and Chemical Corporation.

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SALES REPRESENTATIVES IN PRINCIPAL CITIES

BOSTON PROGRAM

(Continued from page 54)

Introduction to Low Temperature Symposium Series, F. E. Pavlis, Air Products Inc., Allentown, Pa.

Gas Prepurification for Low Temperature Processing, N. C. Updegraff, The Girdler Co., Louisville, Ky.

In preparing gases for low temperature processing it is necessary to remove impurities that have higher liquefying or freezing points than the temperatures to be reached during processing. The problems are discussed, examples analyzed.

Low Temperature Distillation, L. A. Wenzel, Lehigh Univ., Bethlehem, Pa.

Design details, with examples and problems, of columns and other low temperature equipment. Interpretation of high temperature column data is all but useless.

Low Temperature Refrigeration, J. L. Cost, Air Products, Inc., Allentown, Pa.

Low temperature refrigeration at liquid air temperatures requires on the order of 30 times the power and 50 times the cost of refrigeration at ice temperatures. How this is done is analyzed in this paper.

Low Temperature Heat Exchange, W. E. Gifford, Arthur D. Little, Inc., Cambridge, Mass.

In low temperature equipment it becomes necessary to achieve heat exchanger efficiencies much higher than in applications near or above room temperatures. Types of heat exchangers used, and special problems, are discussed.

Properties of Materials at Low Temperatures, R. J. Corruccini, National Bureau of Standards, Boulder, Colo.

Mainly devoted to the thermal and mechanical properties, since these are considered to be of the greatest importance in cryogenic engineering, this paper will also discuss electrical and magnetic properties, insulation properties, and others.

CHEMICAL ENGINEERING IN THE PULP AND PAPER INDUSTRY, E. C. Bowen, Bowen Corp., Cambridge, Mass., presiding. (Simultaneous with Low Temperature and General Papers V).

In a fully integrated mill, the pulp and paper industry uses all of the chemical engineering unit processes. This symposium is designed to lay a foundation for future symposia of a more technical nature on the subject of what is now our fifth largest industry, Canada's first largest.

The Pulp and Paper Industry, G. Olmstead, Jr., S. D. Warren Co., Boston, Mass.

Description and analysis of the industry and its phenomenal growth emphasizing the chemical engineering problems which lie ahead.

Undergraduate Training In Chemical Engineering, L. C. Jenness, Univ. of Maine, Orono, Me.

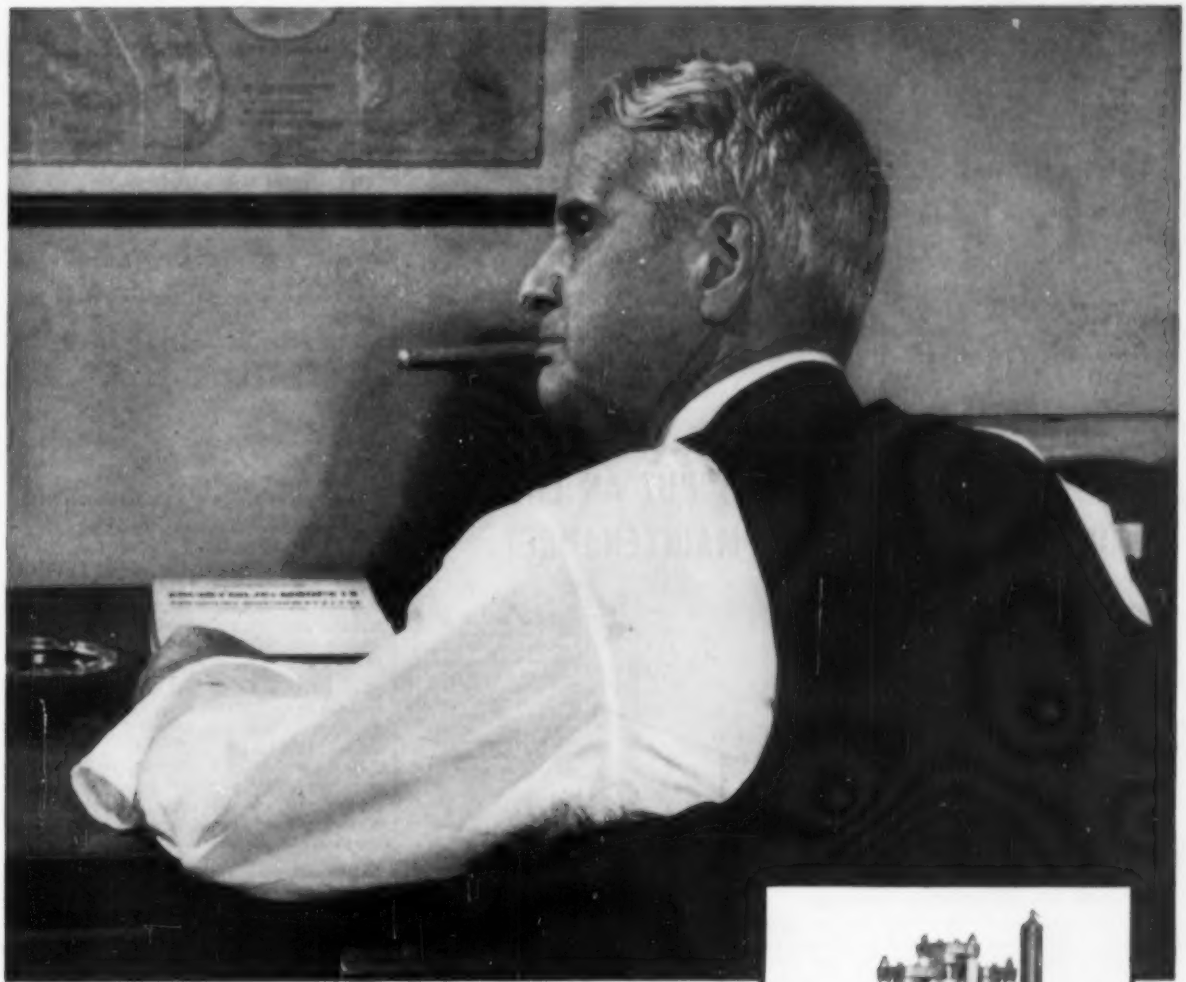
Undergraduate chemical engineering curricula and their relation to pulp and paper. Special curricula which stress pulp and paper are identified and described.

Graduate Training and Research in Chemical Engineering, R. P. Whitney, The Institute of Paper Chemistry, Appleton, Wisc.

General discussion of graduate work in chemical engineering with a stress on pulp and paper work, and a detailed presentation of the program of the Institute of Paper Chemistry.

Revolutionary Trends in Pulp and Paper Technology, L. R. Thiesmeyer, president, Pulp and Paper Research Institute of Canada.

(Continued on page 58)



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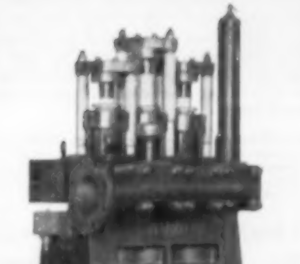

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The above illustration shows the "in-line" vent located inside the tank house some 20 ft. from the open end of the line. This avoids frequent, costly and highly dangerous roof-top inspection formerly necessary where vents were installed outside at the end of the vent lines.

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The development of this "in-line" flame arrester vent is typical of Protectoseal design and engineering versatility. In providing proper fire and explosion protection, consideration is always given to the operating and maintenance problems of corrosion, sublimation, valve pressures, conservation of solvent vapors, cleaning of flame arresters and other special problems.

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For a fuller understanding of how Protectoseal can help you solve your venting problems, fill out coupon below for your copy of the complete Venting Manual showing operating features and special applications of the complete Protectoseal line.

*The 1" in-line Flame Arrester Vent is approved for installations at distances up to 50 ft. from the open end of vent lines from flammable liquid storage and process tanks; 2" and larger sizes are approved for installation at distances up to 20 ft. from the open end of vent lines.

(a) Open end of vent line to atmosphere. (b) Protectoseal "in-line" Vent with removable flame arrester assembly. (c) Continuation of vent line to storage tank. (d) Rodding and sampling opening protected with Protectoseal #406D Rodding and Sampling Head.

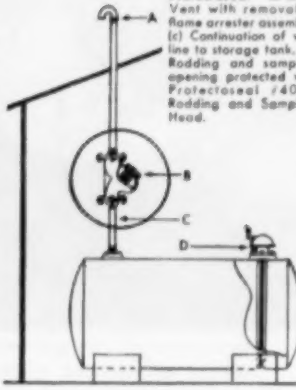

Diagram shows actual installation of the Protectoseal "in-line" Flame Arrester Vent. Note how the vent is installed inside the tank house.

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BOSTON PROGRAM

(*Continued from page 56*)

Long an "art," pulp and paper making is on the verge of a technological revolution into a full-fledged science, and the key man is the chemical engineer.

Panel Discussion, J. W. Hemphill, Johns-Manville; H. G. Ingraham, Chas. T. Main, Inc.; W. A. Ketchen, The Fraser Companies, Ltd.; W. Pittam, Stone & Webster; R. A. Springer, Diamond Alkali.

GENERAL PAPERS—V, J. N. Addoms, Atlas Powder Co., Wilmington, Del., presiding. (Simultaneous with Low Temperature and Pulp and Paper symposia).

Thermal Conductivity—Reduced State Correlation for the Inert Gases, E. J. Owens and G. Thodos, Northwestern Tech. Institute, Evanston, Ill.

The fragmentary thermal conductivity data available in the literature for argon has been correlated using a residual thermal conductivity vs. density relationship, and this has been used to construct an extensive reduced state chart.

A Study of Laminar-Flow Heat Transfer in Tubes, J. F. Gross and H. C. Van Ness, Purdue Univ., Lafayette, Ind.

The general problem of heat transfer to fluids in laminar flow in tubes is discussed and a new procedure for the measurement of local laminar-flow heat-transfer coefficients is described.

Effect of Wall Roughness on Convective Heat Transfer in Commercial Pipes, J. W. Smith and N. Epstein, Univ. of British Columbia, Vancouver, B.C., Can.

Heat transfer and fluid friction measurements were made for air flow through a smooth copper pipe and six other commercial pipes whose ratio of diameter to equivalent sand roughness varied from 640 to 64.

An Approximate Theory for Predicting Minimum Superheat for Ebullition, S. G. Bankoff, Rose Polytechnic, Terre Haute, Ind.

An approximate theory is derived for predicting superheats required for initiation of ebullition at low pressures, based on the criterion that the wall drag, rather than the velocity of the temperature wave, determines the rate of penetration of the liquid into the capillary roughness element.

Heat Transfer in the Critical Region, R. P. Bringer and J. M. Smith, Purdue Univ., Lafayette, Ind.

Experiments were made on the heat transfer coefficients of carbon dioxide in the critical region, existing empirical and semi-theoretical correlations were found inadequate in this region, and a simplified procedure was proposed for estimating heat transfer coefficients in the critical region.

LABORATORY FACILITIES FOR NUCLEAR ENGINEERING EDUCATION, J. J. Martin, Univ. of Michigan, Ann Arbor, Mich., presiding. J. F. Kaufmann, Div. Reactor Development, A.E.C., co-chairman.

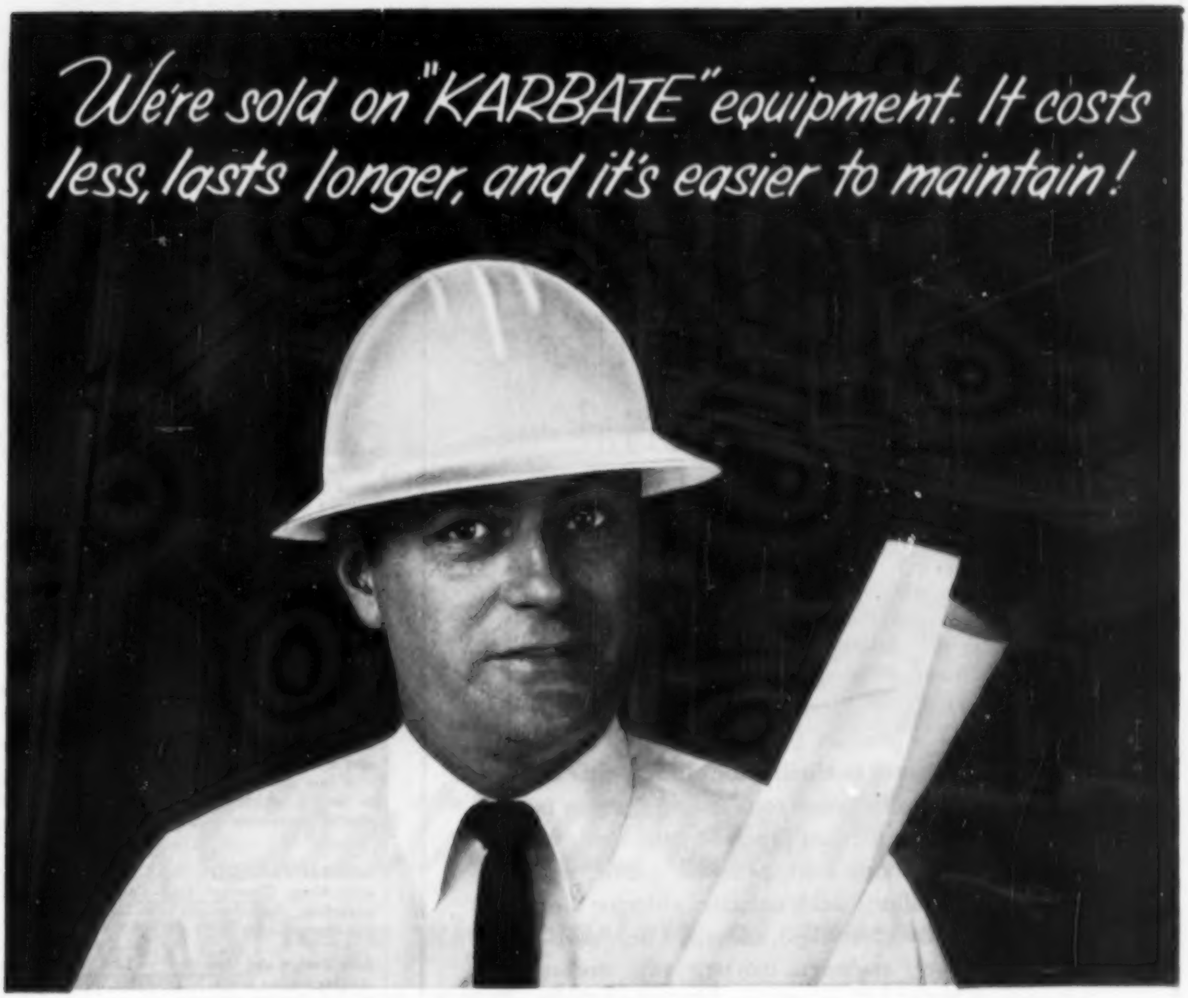
Nuclear Science Laboratory Facilities at the Pennsylvania State University, R. G. Cochran, Penn. State Univ., State College, Pa.

All Penn State's nuclear science courses are directly or indirectly concerned with the use of the university's research reactor.

Laboratory Facilities for Nuclear Engineering Education at MIT, T. J. Thompson, MIT, Cambridge, Mass.

A well-established and well-rounded set of lectures, plus newly established laboratory courses, will be enhanced when MIT finishes construction of its one megawatt heavy water

(*Continued on page 60*)



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BOSTON PROGRAM

(*Continued from page* 58)

cooled and moderated research and teaching reactor.

Laboratory Facilities for Nuclear Engineering Education at the University of Michigan, A. H. Emmons, H. J. Gomberg, W. Kerr, and R. B. Messler, Univ. of Michigan, Ann Arbor, Mich.

Michigan's laboratory facilities, their cost, application and integration into the curriculum, including data on a radiochemical laboratory, a high-level materials handling cell, and a 1,000 kw "swimming pool" reactor.

Laboratory Experiments in Nuclear Engineering at North Carolina State College, A. W. Waltner, J. T. Lynn and R. L. Murray, North Carolina State College, Raleigh, N. C.

The three laboratories, provided to cover the topics of nuclear physics, radioactivity, and the nuclear reactor are discussed.

Laboratory Facilities for Nuclear Engineering Education at Iowa State College, M. Smutz, Iowa State College, Ames, Iowa.

Iowa State is in a unique situation because the Ames Laboratory for Atomic Research, an AEC national laboratory, is located on the campus. Most major staff members have dual duties—teaching and on the laboratory staff—and facilities of both the college and the laboratory are excellent.

Part I—The Pickle-Barrel Reactor, H. Ager-Hansson, NYU, New York.

The first subcritical reactor in operation as a laboratory facility at an American university.

Part II—The Inside-Out Reactor, M. Osredkar and R. Stephenson, NYU, New York.

A low power, high flux reactor for research or testing which consists essentially of a fast reactor containing a central moderator region.

GENERAL PAPERS—VI, H. H. Reynolds, Dewey and Almy Chemical Co., Cambridge, Mass., presiding. (Simultaneous with Laboratory Facilities symposium).

Safe Design and Operation of Low Temperature Air Separation Units, F. G. Kerry, American Air Liquide Inc., New York.

Ozone and nitrogen oxides are important contaminants; vaporizer and filter are critical sites in oxygen production plants.

Flow of Pulp Slurries in Pipes, R. J. Richardson and J. E. Vivian, MIT, Cambridge, Mass.

The rheology of bleached sulphite wood pulp suspensions was studied and the findings applied to the problem of predicting the pressure loss for the flow of this material in pipes.

Penob-Resins from Sulphite Waste Liquor, A. A. Morton, H. S. Hooper, R. J. Snare, and E. S. Packard, Penobscot Chemical Fibre Co., Great Works, Me.

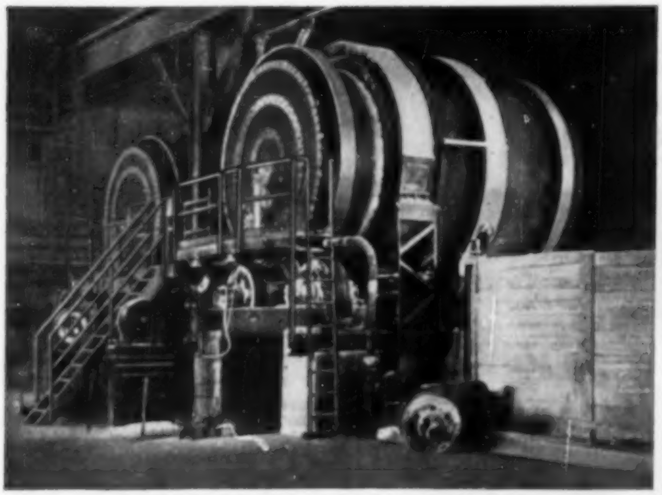
This paper describes some physical and chemical properties of the insoluble, infusible resins produced from the organic solids in sulphite waste liquors, which are named Penob resins.

Drying Aqueous Sodium Sulfate in the Jet Spray Dryer, H. A. McLain, E. W. Comings, and J. E. Meyers, Purdue Univ., Lafayette, Ind.

Description of the drying of sodium sulfate solution in an improved model of the jet spray dryer.

Effects of Atomization on the Performance of a Pilot Spray Dryer, J. E. Gwyn, J. C. Garver, and W. R. Marshall, Jr., Univ. of Wisconsin, Madison, Wisc.

Determination of the effects of four different types of atomization on the air flow, temperature profiles, product recoveries, and heat loss from the dryer.



Two Semi-Continuous Batch Rotary Kilns Pre-heating Electric Furnace Charges.

Two Oil-Fired Rotary Kilns in Midwestern Manufacturing Plant.

Rotary Waste Disposal Kiln Showing Skip Loader and Brick Ash Collection Chamber.

Batch AND *Continuous Kilns*

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Bartlett-Snow batch kilns are ideally suited for pre-heating electric furnace charges. They bring the material up to temperature and remove moisture with a less expensive gas or liquid fuel, and shorten the furnace heating cycle, increasing its output.

Gas or oil-fired continuous kilns are designed for applying ceramic coatings to granules, calcining and nodulizing ores, and oxidizing and reducing operations at temperatures from 1000° F to 2200° F. Cylinder rotating speed can be varied to control the time the material is under treatment. Burners are controlled automatically with radiation pyrometers. Heated material can be cooled in separate equipment at gradually declining temperatures if desired.

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TECHNOLOGY OF FUTURE TAKING SHAPE AT NEW NATIONAL CARBON LABORATORIES

TURN FOR MORE NEWS ON
INDUSTRY ....page 64 et seq.
NUCLEAR ....page 86
INSTITUTIONAL ....page 92
RESEARCH ....page 98

Parma, Ohio, research laboratory dedicated Sept. 18 in ceremony attended by company officials, guest speakers, and members of technical press.

Electric power directly from fuels by chemical means; custom-built catalysts for chemical process reactions: these are only two of the long-term goals of the widely diversified basic research program being pushed at the new Parma, Ohio, labs of the National Carbon Co., a division of Union Carbide and Carbon.

● **"Welded" Graphite:** Already achieved at Parma is a method of welding graphite which is expected to have important industrial applications, particularly in the construction of nuclear reactors. Method is based on heating graphite under pressure to prevent sublimation.

● **Giant Crystals:** The largest single crystals of cadmium sulfide ever reported have been grown in the new labs. A light-sensitive material, cadmium sulfide is used in photo cells and in solar batteries. Photo conducting properties of single crystals have been found to be superior to those of poly-crystalline films. Laboratory crystals three-eighths of an inch in diameter and several inches long have been produced by newly-developed techniques.

● **Power Directly from Fuel:** Fuel cells, consisting perhaps of a special carbon electrode in a gas element, could supply electrical power for industrial uses. This project ranks high on the long-range program at Parma.

● **Custom-built Catalysts:** By intensive study of surface reactions, particularly at low temperatures, National Carbon researchers hope to achieve the design of catalysts for special purposes, on the basis of applied scientific theory.

This is a model of what the tip of an extremely sharp tungsten needle would look like if magnified 100,000,000 times. Model is used to simulate surface reactions in the basic study of catalysts. The dark marbles represent molecules of oxygen attached to the tungsten surface.

Emphasis on Solid State Physics

The new labs will concentrate on long-range, pure research in chemical and solid state physics. While nuclear physics is primarily concerned with the core of the atom, solid state physics deals with the electrons surrounding the nucleus. Some of the orbital electrons are free to move within a solid, are influenced by electric or magnetic fields or by light of certain energy or wave length. Since extremes of heat, cold and pressure can also influence the behavior of these electrons, facilities at the new lab are designed to produce all the requisite experimental conditions.

It is felt at Parma that the improvement of existing materials and the creation of new materials calls for an understanding of the nature of matter. Efficient nuclear reactors, new high-temperature refractory materials, miniaturization of electronic components, new electrochemical battery system—all require a thorough knowledge of the molecular, atomic, and sub-atomic make-up of solids.

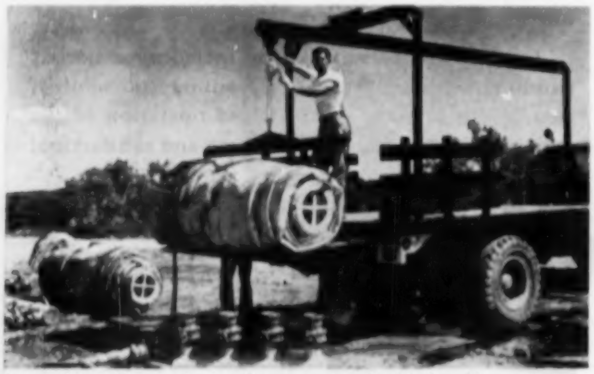
National Carbon is convinced that money spent on pure research will be repaid many-fold.

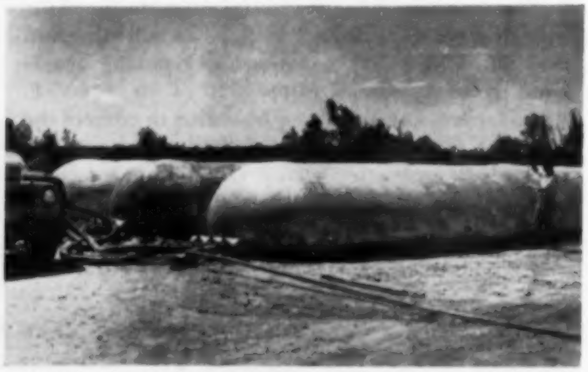
Day-long Dedication Program

High-light of the dedication ceremonies was a symposium on refractory hard metals. Speakers included A. W. Searcy, Univ. of Calif.; R. Smoluchowski, Carnegie Institute; and Pol E. Duwez, Calif. Institute of Technology.

Needed—Special Education for Gifted?

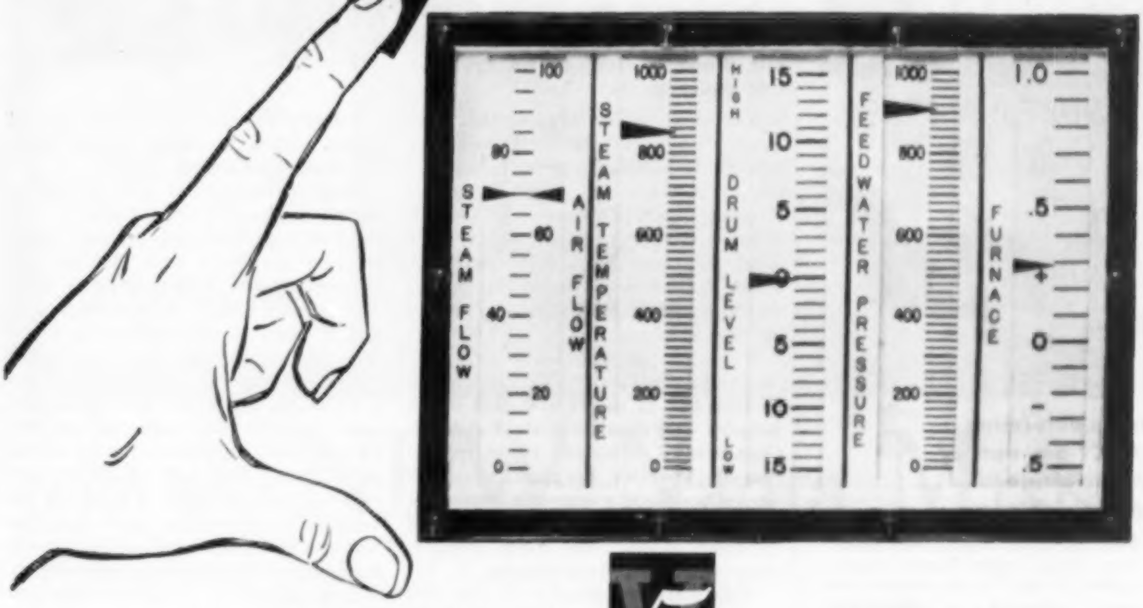
Keynote of the program was an address by James R. Killian, president of M.I.T. So far, said Killian, in the development of our system of public education we have given first attention to providing educational opportunity for all of our young people regardless of their means or their abilities. We must continue to do this, he emphasized, but the next great step should be to provide motivation, reward, and opportunity for those of more than average gifts. Only in this way can the nation avoid any worry about being outpaced in its intellectual achievement.





Collapsible rubber tanks for the storage of liquids have been given their first test in the oil fields of the southwest where they have helped to overcome the transportation and storage problems encountered with steel tanks. The 15,000 gallon tanks, manufactured of a tough, rubberized nylon by the Firestone Tire & Rubber Co. at Magnolia, Ark., fold into a package 8 feet long by 2½ feet in diameter when empty, expand to 45 feet by 11 feet by 6 feet when filled.

announcing a new line of **small-size easy-to-read** gauges and receivers



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- EASILY MOUNTED — no panel drilling necessary in most cases
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- REMOVAL FROM FRONT OR BACK

Now you don't have to sacrifice instrument performance and readability to size considerations. With Republic's new line of small-size V5 Gauges, you can save panel space, make more compact instrument groupings and *still* get the accuracy, sensitivity and readability you would expect from conventional sized instruments. Full sized diaphragms, bellows and helix units in V5 Gauges assure "big" gauge performance in an instrument that requires only one-fourth the panel space of conventional gauges. Five inch scales are almost flat and are indirectly illuminated as a standard feature for easy reading — even from a distance.

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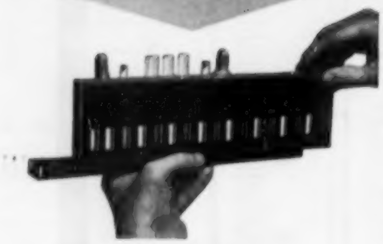

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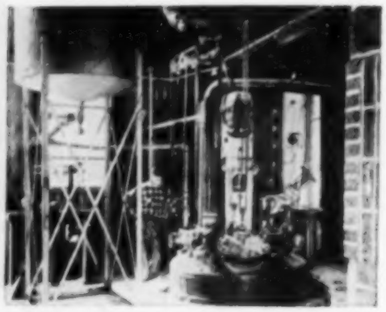
OLEORESIN INDUSTRY MOVES NORTH

A reverse trend market shift occurred recently when Pine Chemicals, Inc., came to New Jersey. Move marks revitalization of an industry once considered dying.

Continuous distillation and refining plant is first of its type in this country.



In a reversal of the prevailing industrial trend, Pine Chemicals has brought the pine oleoresin industry north from Baxley, Ga., where its parent company, Filtered Rosin Products, is located. Reason: Ten-year market study indicated the need for a plant near one of the largest rosin consuming blocks, the paint, paper and chemical industry of the Northeast.

When the Pine Chemicals' plant went on-stream at Fieldsboro, N. J., it marked another step in the rejuvenation of an industry once considered about doomed. Once devoted exclusively to the production of turpentine, the naval stores industry has made a complete turn-about until today pine gum is the source of "building blocks" for many intermediate and finished chemicals.

With what is claimed to be the first commercial plant in the industry to operate continuous distillation, Pine Chemicals gets its raw material from the parent company in Georgia via the inland waterway. Large storage facilities insure year-round operation.

Main advantage of the continuous process is the short time necessary for the gum to pass through the still (about an hour for batch only, five minutes for continuous) which produces rosin that is more nearly in its natural state and is much more reactive—a prime consideration for the chemical industry.

Basic products of the new plant are a very high grade, low acid turpentine, and a superior rosin, both cold and hot. On schedule, hot rosin is drawn off the still directly into tank trucks or tank cars for fresh delivery. Furnishing hot resin to customers in small quantities was one of the basic reasons for moving north and eliminating long rail delivery. A large part of the company's rosin production is not sold, but is used by the company to produce paper size and synthetic resins.

A new process, developed by Lurgi of Germany and offered in the U. S. by Blaw-Knox, Chemical Plants Division, is said to remove the nitric oxide from coke oven gas and make it possible to use the coke oven gas instead of hydrogen in the hydro-desulfurization of BTX. □

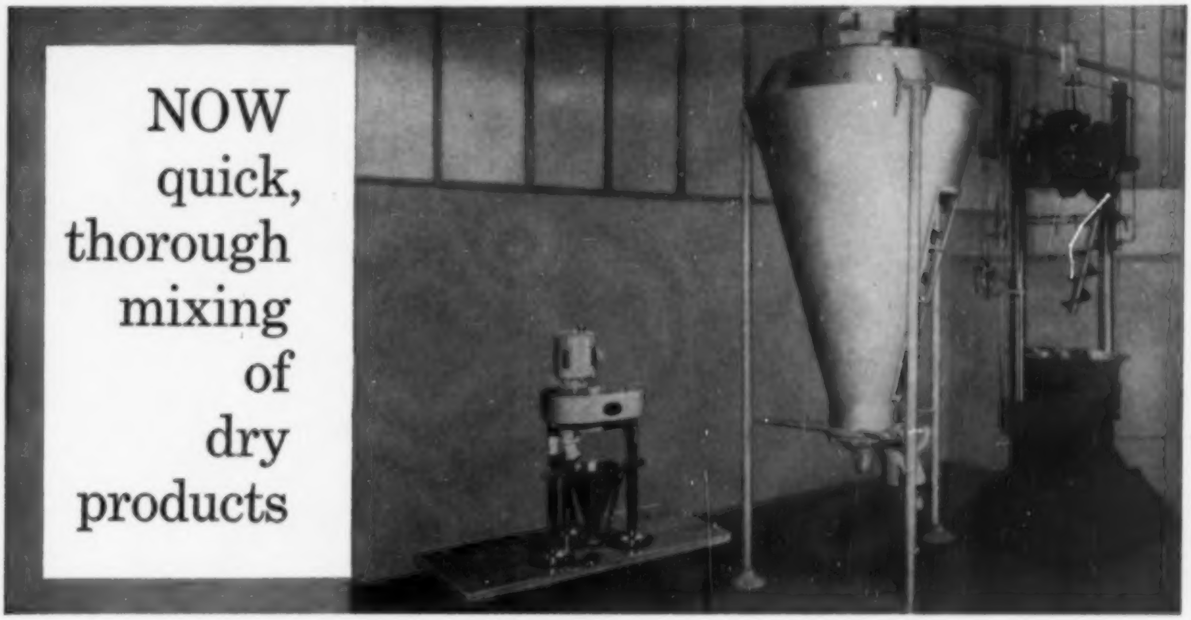
A jointly owned $231 million company to produce 180,000 tons per year of primary aluminum has been formed by Olin Mathieson Chemical Corp. and Revere Copper and Brass, Inc. The company will be known as Olin Revere Metals Corp. □

With respect to hydrocarbons, auto exhaust is a major contributor to air pollution in the Los Angeles Basin. In its technical report on "The Movement of Polluted Air in the Los Angeles Basin," the Air Pollution Foundation stated that a study of air movements on days of heavy smog showed that air reaching places where eye irritation and other effects were experienced did not pass near refineries or other heavy industry in a large proportion of cases. □

A plant to produce vinyl chloride monomer from ethylene will mark Ethyl Corp.'s entry into that field. The multi-million dollar plant will be located at Baton Rouge, La., and will be engineered and constructed by Catalytic Construction Co. Expected to be completed in the latter part of this year, Ethyl's plant will be a substantial addition to present vinyl chloride monomer capacity. □

A five-year agreement for an exchange of information and know-how between the Catalin Corp. of America and Adhesivos Resistol, S.A., of Mexico, has just been signed. Catalin will disclose its formulas and technical information pertaining to phenolic, cresylic, resorcinol, melamine and urea liquid resins, and Adhesivos will give information on any processes it might develop in the same area to Catalin. □

Capacity for the manufacture of methyl methacrylate monomer by Du Pont will be doubled in about two years when expanded facilities are completed. The product is the raw material for "Lucite" acrylic resin products. □



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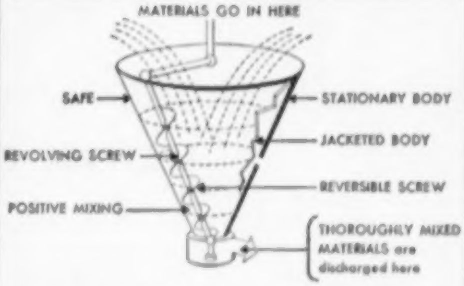

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- Latex mixed with chemicals
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- Paint pigments
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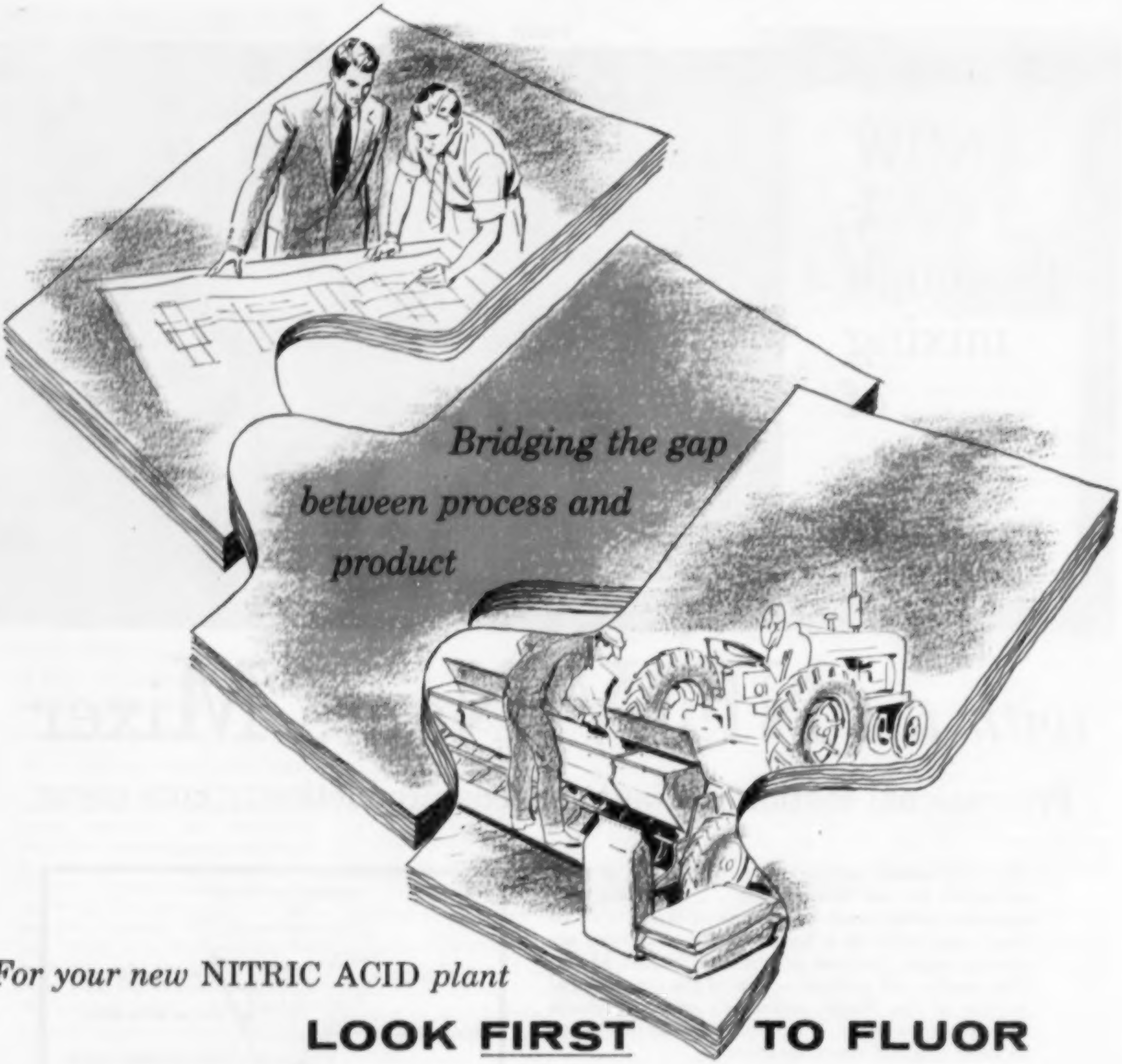
- Starch
- Sugar
- Many other products

The Buflovak Equipment Division of Blaw-Knox Company is the exclusive licensee for the Nauta Mixer. It is built to the same exacting standards for which Buflovak is famous in building evaporators, dryers, autoclaves, kettles and other equipment.

50th Anniversary 1906–1956

BLAW-KNOX COMPANY

Buflovak Equipment Division, 1567 Fillmore Avenue, Buffalo 11, N.Y.



For your new NITRIC ACID *plant*

LOOK FIRST TO FLUOR

For new nitric acid production facilities, you can now call on Fluor, licensed to design and construct plants based on the DuPont Pressure Process. Fluor's long experience in the process industries is your insurance of a nitric acid production facility with low initial cost and trouble-free operation. The Fluor organization's complete integration permits each project to be carried through all phases . . . design, procurement, and construction . . . under a single responsibility.

The process offered is economical and completely proven, using only three raw materials—air, ammonia, and distilled water. Capacity may be as low as 50 tons per day or as high as required. An integral energy-recovery system substantially reduces horsepower requirements, and the plants are characterized by minimum operating costs.

Fluor's unique ability to see every project *as a whole* . . . the economic as well as the technical details . . . is described, along with process description and operating requirements, in a new folder, NITRIC ACID PLANTS. Write for your copy today.

FLUOR

Engineers • Constructors

The FLUOR CORPORATION, Ltd.

2500 So. Atlantic Boulevard, Los Angeles 22, Calif. • Offices in Principal Cities in the United States and Canada

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Advertisers' Products

IFC	3R	4A	6L	7A	8A	10A	11A	12A	13A	14L
15A	16A	17A	18A	19A	23A	24L	25A	26A	27A	28L
29A	30A	31A	32L	33A	34A	35A	36L	37A	38A	39A
40A	42A	43R	44A	45A	46A	48A	49A	50A	396A	398A
55A	56L	57A	58L	59A	60L	61A	63A	64L	65A	66A
71A	73A	75A	77A	79A	81A	82L	83A	84TL	84BL	85R
86L	87R	89L	89R	90L	91R	92L	93TL	93BL	93TR	93BR
95R	96L	97R	98TL	99TL	99BL	99R	100L	100R	101BR	102L
103TL	103BL	103R	105TR	105BR	106TL	106BL	107TR	107BR		
108L	109B	119R	120TL	120BL	120BR	121TR	121BR	IBC	OBC	

Chemical Engineering Progress Data Service

Name ....

Position ....

Company ....

Address ....

City .... Zone ...... State ....

☐ I want a subscription to C.E.P. Bill me $6.00 for a year.

October, 1956

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Advertisers' Products

IFC	3R	4A	6L	7A	8A	10A	11A	12A	13A	14L
15A	16A	17A	18A	19A	23A	24L	25A	26A	27A	28L
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40A	42A	43R	44A	45A	46A	48A	49A	50A	396A	398A
55A	56L	57A	58L	59A	60L	61A	63A	64L	65A	66A
71A	73A	75A	77A	79A	81A	82L	83A	84TL	84BL	85R
86L	87R	89L	89R	90L	91R	92L	93TL	93BL	93TR	93BR
95R	96L	97R	98TL	99TL	99BL	99R	100L	100R	101BR	102L
103TL	103BL	103R	105TR	105BR	106TL	106BL	107TR	107BR		
108L	109B	119R	120TL	120BL	120BR	121TR	121BR	IBC	OBC	

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Name ....

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Address ....

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October, 1956

the chemical engineers' DATA SERVICE and GUIDE

to significant developments in

- EQUIPMENT
- MATERIALS
- SERVICES

developments of the month—

110 Motor-driven Valve Grinder. Savings as high as 400% on labor, increased production, fuel savings, & power gains are some of the benefits claimed by the use of the Motor-driven Dexter Valve Reseating Grinder. This new machine, product of the Leavitt Machine Co., can regrind any globe or gate valve from ¼ in. to 12 in. without removing the valve from the line.

Through the use of a high-speed motor, & recently developed abrasive elements, the machine can grind the seat of any valve regardless of material hardness. The grinding elements, made in the form of cones & segments, are mounted on various size rubber-coated grinding heads which can be changed for various size valves.

Since one man using the new machine can grind any valve right on the line, the need for 3- or 4-man crews to remove & replace defective valves is completely eliminated.

(Continued on page 68)

TURN THIS PAGE TO RIGHT FOR MORE . . .

HOW TO USE THIS POST CARD FOLDER

Merely encircle numbers on cards to get literature desired. On advertised products in front of magazine, fold this page out to right. For those in back, fold card strip again to right, where card strip is scored for detaching.

products-

advertised in this issue

IFC Process Equipment. Top quality welding is characteristic of Vulcan towers, exchangers, kettles, condensers, etc.

3R Feeders. Draver Feeders for bulk materials save power & production time, avoid excessive equipment wear. B. F. Gump Co.

4A Demisters. Separation efficiency & throughput of distillation equipment is improved by Yorkmesh Demisters. Otto H. York Co.

6L Industrial Filter. R. P. Adams Co. IWF filters available in wide range of sizes & multiple combinations.

7A Ammonia Plants. Foster Wheeler-designed & built Casale process ammonia plants feature the Casale ejector, eliminating recirculating compressor.

8-9A Centrifugal Pumps. Standardization of parts permits 70,480 combinations in Worthington SESC pumps. Bulletin.

10A Pan Filters. Eimco pan filters offer clean, full cake discharge & absolute separation of wash. Wide range of materials & sizes.

11R Hard Rubber Equipment. Ace piping, pumps, valves, & tanks, made of or lined with hard rubbers, keep equipment on stream full time. American Hard Rubber Co.

12A Conveyors. Sandvik continuous water-cooled steel-belt conveyors offer outstanding process advantages.

13A Teflon Expansion Joints. Made of Du Pont Teflon, expansion joints & other fittings are designed for service at elevated temperatures & pressures.

14L Mechanical Seals. Chemiseal mechanical seals with pressure-balanced Teflon bellows unit last longer. United States Gasket Co.

15A Ceramic Packing. Intalox Saddle Packing, made by U. S. Stoneware, provides more surface area & better liquid distribution.

16A Reaction Vessels. For sound engineering & skilled workmanship consult Bethlehem Foundry & Machine Co.

17A Heater Tubing. Babcock & Wilcox process heater tubing insures maximum corrosion & oxidation resistance.

18A Mercury Arc Rectifiers. Two-circuit construction guarantees optimum operation. Allis-Chalmers.

19-22A Essay Contest. Victor Chemical Works is sponsoring a nation-wide essay contest aimed at stimulating scientific interest on the part of high school graduates. Many prizes.

23A Carbon Products. Great Lakes Carbon Corp. electrodes, anodes & mold stock are machined with the utmost precision.

24L Phenoline 305. Heavy duty maintenance protection in severe corrosive atmospheres for structural steel & equipment. Carboline Co.

25A Crystallizers. "Krystal" crystallizers, product of Struthers Wells, are engineered for economy in every detail.

26A Construction Services. Plants for chemical processing, nucleonics, oil refining, petrochemistry, power, steel. Graver Construction Co.

27A Controlled Volume Pump. The Pulsafeeder combines the good features of both piston & diaphragm pumps. Lapp Insulator Co.

28L Heat Exchangers. The Niagara Aero Heat Exchanger cools liquids & gases by evaporative cooling with atmospheric air. Niagara Blower Co.

29A Petroleum Processes. Design & engineering of all types of plants for the petroleum industry. Blaw-Knox.

30A Controlled Volume Pumps. Specially adapted for metering process additives. Milton Roy Co.

31A Sulfur Recovery. Ralph M. Parsons Co. has designed & constructed more than 30 plants for recovering sulfur from H_2S.

32L Heat Exchangers. Highly-efficient, easily installed, easily maintained, extended-surface heat exchangers. Aerofin Corp.

33A Compressors. Ingersoll-Rand offers a full line of centrifugal & reciprocating compressors.

34A Drying Equipment. All types of drying equipment for the chemical processing industries. Proctor & Schwartz.

35A Vinyl Acetate Plants. New \$3,000,000 plant, engineered & constructed by Lummus, has recently been put on stream.

36L Metering Feeders. Manzel lubricators, chemical feeders, slurry pumps, are used wherever liquids must be metered with accuracy.

37A Molybdenum Catalysts. High selectivity is outstanding feature of molybdenum catalysts made by Climax Molybdenum.

38A Valves & Fittings. Crane quality design, materials, assembly & testing assure low cost flow control service.

39A Fiber & Film Processing. Heat-sensitive fiber & film materials of high viscosity processed better at lower cost with Votator apparatus. Girdler Co.

40-41A Celite. Exceptional performance characteristics in wide range of process applications. Johns-Manville.

42A Plastic Rotary Pump. Plastic pumps of polyethylene, Buna N, or Bakelite for all types of corrosive applications. Vanton Pump & Equipment Corp.

43R Swivel Joints. Emsco Ball Bearing Swivel Joints provide free turning, efficient pack-off, long life. Emsco Manufacturing Co.

44A Technical Literature. Big selection of technical manuals, selection charts, etc. on pumps & valves. Cooper Alloy Corp.

45A Catalysts. Girdler offers application, development, analytical, market & advanced production services.

46A-47L Control Valves. Black, Sivalls & Bryson present an all-new line of diaphragm control valves. Many new features.

48A Photochemical Equipment. Increased output, substantial production savings, are reported with Hanovia photochemical equipment.

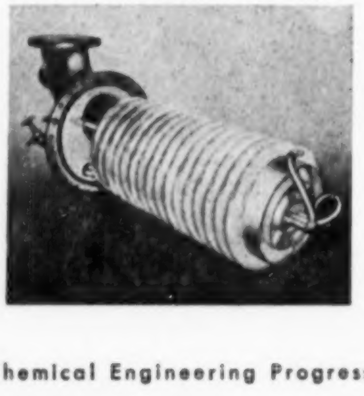
49A Turbo Dryer. Wyssmont offers a continuous, closed circuit turbo dryer with many process advantages.

50A Water Cooler. Croll-Reynolds "Chill-Vactor" proves ideal for furnishing chilled water in manufacture of pulp by chlorine dioxide bleaching.

396A Reducing Valve. An air-loaded, diaphragm-operated pressure reducing valve which is virtually maintenance-free. Leslie Co.

398A Hermetic Centrifuge. The De Laval 244 Hermetic Centrifuge is designed for the effective & economical separation or clarification of viscous, inflammable, or "free from contact with air" materials.

DEVELOPMENTS OF THE MONTH *(Continued)*



111 Heat Exchanger Coil. New type heat exchanger, manufactured by Schutte & Koerting Co., contains 540 square feet of heating surface but occupies only 7.2 cubic feet of space. The unit will heat 3,000 cubic feet of vapor per minute, using 450 lb./sq.in. steam inside the coils.

Size of the radiafin coil bundle is only 40¾ in. long by 19¾ in. in diameter. Inside are three banks of hot-dip galvanized steel radiafin coils. Each bank of coils is separated by a rolled steel cylinder which provides a baffle & support for the coils.

In fabricating the unit, the tubes were first finned & then formed into coils.

Literature & consulting services are available.

(Continued on page 69)

DEVELOPMENTS OF THE MONTH *(Continued)*

55A Turbo Mixer. Product of Turbo Mixer Division of General American Transportation Corp., this equipment is built for continuous heavy duty service.

56L Process Equipment. All types of heat transfer & process equipment. Manning & Lewis Engineering Co.

57A Pumps. Aldrich Direct Flow design, with fluid-end sectionalization, offers substantial economies in operation & maintenance. Aldrich Pump Co.

58L Tank Safety Equipment. Complete line of fire & explosion prevention equipment. Venting manual available. Protectoseal Products.

59A Karbate Equipment. Lower first cost, sustained low maintenance, immunity to thermal shock, high thermal conductivity. National Carbon Co.

60L Tantalum. Tantalum can save money in processing hydrochloric acid, nitric acid, bromine, chlorine, etc. Fansteel Metallurgical Corp.

61A Kilns. Batch & continuous kilns for a wide variety of pre-heating, processing & disposal operations. Bartlett-Snow.

63A Small Size Gauges. Complete line of small size gauges & receivers. Republic Flow Meters Co.

64L Colorimetric Analysis. The Taylor Comparator assures accurate & quick pH & chlorine control. Durable, lightweight, portable. W. A. Taylor Co.

65A Mixer. Precessional motion of new Nauta Mixer speeds production, cuts costs. Blaw-Knox Co.

66A Nitric Acid Plants. Fluor Corp. offers single responsibility for design, procurement, construction.

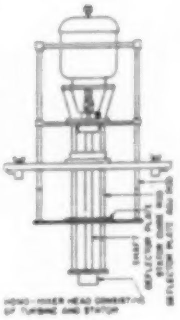
71A Heat Transfer Equipment. Patterson Kelley offers the utmost in experienced thermal design, fabrication & testing.

73A Process Equipment. Conkey crystallizers, evaporators, & filters. Chicago Bridge & Iron Co.

75A Filters. Process Filters, Inc. builds filters of all types to meet any processing need.

77A Filters. Dollinger filters are adaptable to any problem regardless of temperature, pressure, or corrosion factors.

79A Glassed Steel Equipment. Wherever product purity is vital, Pfaudler glassed steel equipment is indicated.



HOMO-MIXER HEAD CONSISTING OF TURBINE AND STATOR

112 Homogenizer-Mixer. A high-speed, high sheer homogenizer-mixer which assures fast & thorough blending is announced by Gifford-Wood Co. Design minimizes entry of excessive air & formation of air vortexes in the blending operation, permitting formation of more stable emulsions. The Eppenbach Homo-Mixer uses a rotor-stator mechanism that draws material only from the bottom of the containing vessel, thus eliminating vortex & surface boil. Adjustable deflector plate, positioned above the mixing element, directs the material back down into the mixing area, keeps introduction of excessive air at a minimum. Capacities range from 1/4 to 2,000 gal.

(Cont. on page 70)

Numbers without letters indicate data available as described in Data Service "Briefs." Numbers with letters refer to further data concerning products advertised in this issue. Letters indicate position of advertisement on page (if more than one on a page)—L, left; R, right; T, top; B, bottom; A indicates full page; IFC, IBC, and OBC are cover advertisements.

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BUSINESS REPLY CARD
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No Postage Stamp Necessary If Mailed in the United States

CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

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CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

products-

advertised in this issue (Cont.)

81A Filteraids. Dicalite provides a complete range of dependable, uniform filter aids to meet any filtering requirements. Great Lakes Carbon Corp.

82L Chemical Engineering Catalog. Manufacturers' data on equipment, materials of construction & engineering services. Reinhold Publishing Corp.

83A Dry Processing Equipment. Pulverizers, jaw crushers, crushing rolls, rotary crushers, etc. Sturtevant Mill Co.

84TL Skin Irritant Protection. "Kerodex" offers protection against irritation from epoxy resins, solvents, etc. Ayerst Laboratories.

84BL Nozzles. Nozzles with capacities from 1/8 pint/min. to 4,000 gal./min. Spray Engineering Co.

85R Regulators. Complete line of temperature & pressure regulators. Foster Engineering Co.

86L Pumps. The Motorpump, Ingersoll-Rand product, will do the same work at lower cost.

87R Metal Hose Couplings. Packless reusable couplings are fitted without heat by a simple mechanical process. Packless Metal Hose Inc.

89L Dryers. Long experience in design & building of all types of dryers is offered by C. G. Sargent's Sons Corp.

89R Belt Conveyors. Saco sectional belt conveyor includes all component parts for quick assembly in your plant. Stephens-Adamson.

90L Haveg Equipment. Haveg tanks, fume ducts, hoods, stacks, fans & fittings are suited to handling corrosive fumes & gases. Haveg Industries.

91R Process Equipment. Heat Exchangers, condensers, evaporators, jet ejectors, steam generators, pressure vessels. Condenser Service & Engineering Co.

92L Fluid Mixers. "Packaged" fluid mixers comprise gear reducers, motors, motor supports, couplings, shafts, impellers, base mountings, preassembled for quick easy installation. Philadelphia Gear Works, Inc.

93TL Reflux Heads, Redistributors. Automatic reflux head, made by Distillation Engineering Co., is explosion-proof, electrically-operated for high vacuum.

93TR Used Panel Board Machinery. Automobile panel board machinery for sale. Used only 10 months. United Paper Machinery Corp.

93BL Gear Pumps. SK Gear Pumps, made by Schutte & Koerting, represent years of research & engineering experience.

93BR Spray Nozzles. Properly engineered, precision machined spray nozzles can improve performance. Spraying Systems Co.

95R Scale Feeders. Accurate continuous blending over a wide feed range. Wallace & Tiernan.

96L Teflon Products. Teflon thin-wall tubing is unmatched in corrosive service. Custom molded Teflon in thin sections & shapes also available. Sparta Mfg. Co.

97R Strainers. Strainers for every industrial use, covering pipe sizes from 1 to 24 in. Elliott Co.

98TL Fullers Earth. Florida Fullers Earth, marketed as Florex, has maximum surface area & adsorption efficiency. Floridin Co.

99TL Gear Lubricant. Maris open gear spray lubricant is economical, easy to use. Rothlan Corp.

99BL Rotary Pump. The Eco All-Chem rotary pump is a low cost, low volume pump for corrosive liquids. Eco Engineering Co.

99R Conveyor Drives. U. S. Electrical Motors' Varidrive give added versatility to conveyors in all types of industry. Available in sizes from 1/4 to 60 hp., speeds 2 to 10,000 rev./min.

100L Plastic Pipe, Fittings, Valves. Available in PVC (unplasticized, unmodified polyvinyl chloride), styrene copolymer, & Buna N (acrylonitrile-butadiene). Vanton Pump & Equipment Corp.

100R Nickel Alloy Fabrication. Misco Fabricators are designers, builders, fabricators of heat resisting alloy & stainless steel equipment.

101BR Research & Development Jobs. Jet Propulsion Laboratory has jobs for physicists, engineers, chemists, metallurgists, mathematicians.

102L Silicone Defoamer. New Antifoam B gives the ultimate in foam-killing convenience. Dow Corning Corp.

103TL Penetrating Oil. Maris Aero Spray Oil is speedy, economical & versatile. Rothlan Corp.

103BL Heat Transfer Units. Heat exchangers & coolers for the petroleum, power & chemical processing industries. Schutte & Koerting.

103R Polyethylene & Polyvinyl Chloride Equipment. Lighter weight, easier installation, longer life, lower initial cost, greater rigidity & strength. American Agile Corp.

105TR Fused Quartz. Amersil Co. is headquarters for fused quartz & silica of the highest possible purity.

105BR Vacuum Gauges. Hastings-Raydist vacuum gauges set new standards of accuracy, stability, response.

106TL Water Demineralizers. Barnstead Still & Demineralizer Co. can furnish the right equipment for your needs.

106BL Liquid Handling. Bowser "liquid automation" equipment solves many metering, filtration & blending problems.

107TR Stills. Complete water purification service is available from the Barnstead Still & Demineralizer Co.

107BR Packings. Durametallic Packings provide longer life & satisfactory sealing service. Durametallic Corp.

108L Air Control Equipment. Combination plastic bowl & dehumidifier provides cleaner air, closer regulation, automatic draining, automatic lubrication. Ace Glass Inc.

109R Heat Exchangers. Corrosion-resistant exchangers in stainless, nickel, nickel alloy, aluminum bronze, carbon. Downingtown Iron Works.

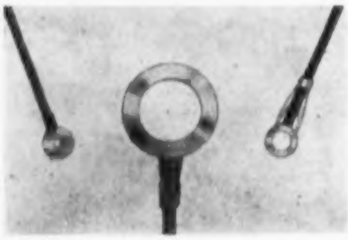
119R Filter Presses. Filter presses in every style & size, for every filtration need. D. R. Sperry.

120TL Aluminum Grating & Walkways. High strength, non-corrosive Waco walkways & handrailing provide complete non-skid, non-sparking safety. Washington Aluminum Co.

(Continued on page 72)

DEVELOPMENTS OF THE MONTH *(Continued)*

114 Miniature Gasket Thermocouples. Designed originally for use beneath spark plugs of internal combustion engines, gasket thermocouples are now used extensively to measure skin temperatures in chemical & food processing, metal working, atomic energy, and many other industries.

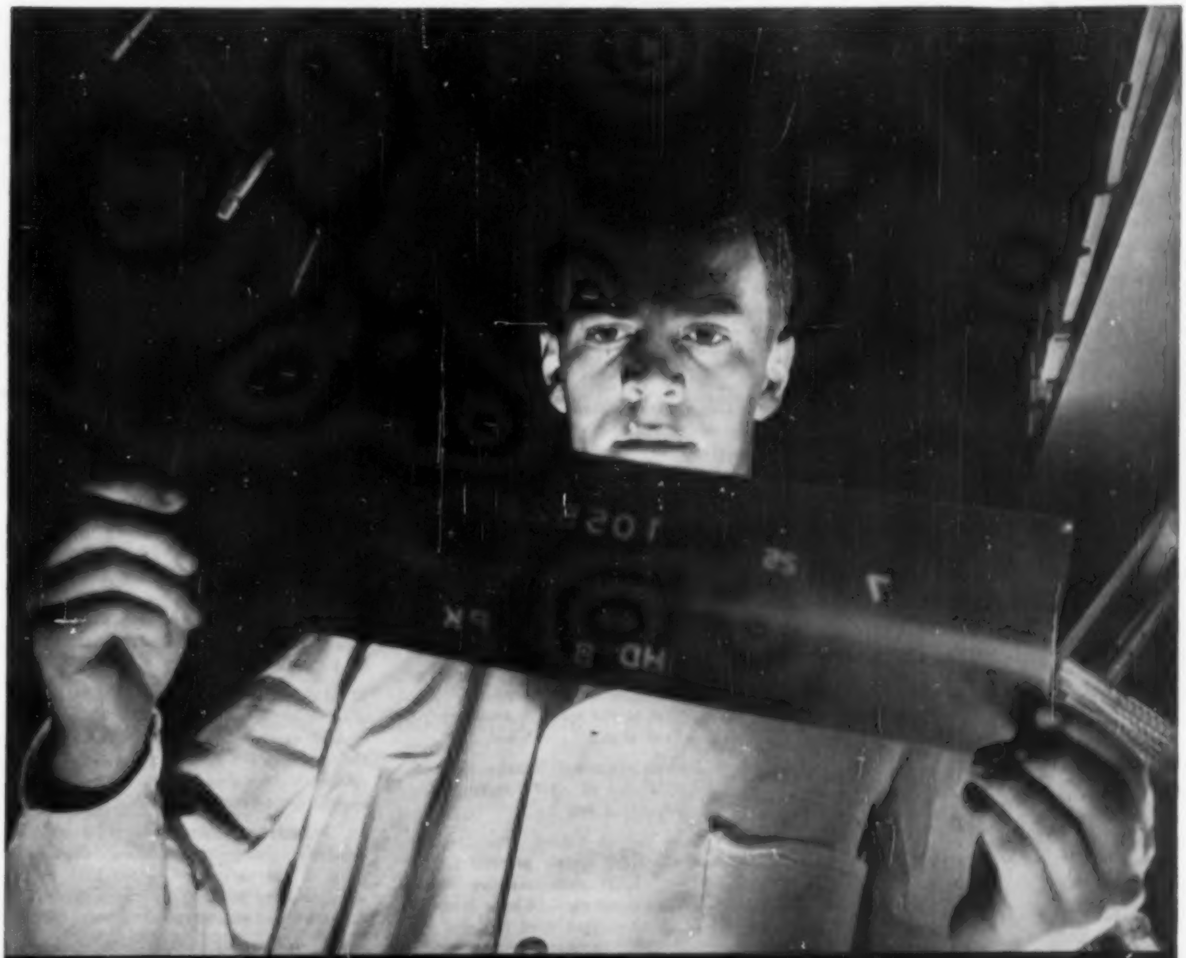


Thermo-Electric Co. offers these gasket thermocouples in three ranges: $-300°$ to $600°$ F. with copper-constantan calibration & copper gasket; $75°$ to $900°$ F. with iron-constantan calibration & copper gasket; & $900°$ to $1200°$ F. with iron-constantan calibration & stainless steel gasket.

Gaskets in the form of standard SAE plain, medium washers in 14 different hole sizes from 5/32" to 1-1/16" I.D.—also 10, 14, & 18 millimeter diameters.

In application, a gasket thermocouple is locked in place on a stud or bolt located in the area of desired temperature measurement or control, & the entire assembly covered with thermal insulation.

(Continued on page 72)



INSIDE STORY:

Why a Heat Exchanger Poses for an X-ray

This technician is giving a clean bill of health to a completed weld on a P-K heat exchanger. Like the x-ray of your chest, this x-ray picture is designed to pick up flaws before they have a chance to become harmful.

Pinholes, lamination, slag inclusions, and all other symptoms of failure are ruled out by this process, which is used to scrutinize the "inside" of *every weld.* Such radiographs are indispensible in manufacturing pressure vessels that will meet every test of time and use. Each x-ray is checked by a representative of the Hartford Steam Boiler Inspection and Insurance Company—for further insurance that every P-K heat exchanger meets or exceeds the rigid standards of the 1952 ASME Code for Unfired Pressure Vessels.

But weld x-rays at P-K represent only a *precaution.* They don't speak for the fact that all P-K welders are ASME qualified for a total of more than 50 types of welding procedures—meaning that the likelihood that flaws will occur at all is minimized. Nor can you see in an x-ray photo the incredibly careful design and calculation that goes into every P-K pressure vessel, to assure that it will be *thermally* and *physically* correct in every way.

Add this all-important knowledge of thermal design to P-K's fabricating and testing procedures, and you have what makes P-K heat transfer equipment different—and better—than all the rest.

Like proof? We'd be delighted to receive your inquiry. The Patterson-Kelley Co., Inc., 1800 Hanson Ave., East Stroudsburg, Penna. Offices in principal cities.

Patterson Kelley

Chemical and Process Division

2580

Twin Shell Blenders • Autoclaves • Pilot Plants • Heat Exchangers • Ribbon and Double Cone Blenders • Lever Lock Doors

products-

advertised in this issue *(Cont.)*

120BL Distillation Literature. Distillation literature, index & abstracts. 780 subject headings. Applied Science Laboratories.

120BR Technical Data Books. Pocket size, loose leaf. Wide range of subjects. Lefax Publishers.

121TR Attrition Mills. Bauer Bros. single disc attrition mills are used for granulating, fluffing, blending, texturizing, mixing, fiberizing, grinding.

121BR Filter Paper. Use of Eaton-Dikeman filter paper as a "cover" over the filter medium can provide finer filtration while protecting the medium.

IBC Coolers. Double tube coolers can increase efficiency of high pressure desuperheating, condensing & gas cooling. Brown Fintube Co.

OBC Mixers. Complete line of "Lightnin" mixers for all industrial purposes. Mixing Equipment Co.

***Technical Literature* •**

materials-

1 Aluminum Handbook. Comprehensive reference handbook from Aluminum Co. of America. 176-page book on mechanical, tensile & chemical properties of aluminum alloys.

2 Tank Linings. Laybond Hypalon, product of Broadway Rubber Corp., offers protection to corrosives at 200° F. and higher. Data sheet on chemical resistances.

3 Propionaldehyde. Technical bulletin giving physical properties, specifications, shipping data, applications, toxicity, typical reactions. Carbide & Carbon Chemicals Co.

4 Polyvinyl Acetate Emulsions. 18-page booklet gives properties and characteristics of Gelva polyvinyl acetate emulsions for use in paints. Shawinigan Resins Corp.

5 Pump Seal Selector. Rotating type selector automatically gives proper materials of construction for various services. Sealol Corp.

6 Fiberglas Products. 132-page publication describes Fiberglas pipe, ducts, other equipment. Removable sheet manual includes 21 graphs, 104 photos, 84 sketches, 74 tables. Owens-Corning Fiberglas Corp.

7 Sodium Orthosilicate. Booklet (8-page) presents physical & chemical properties, packaging & safety precautions. Dow Chemical Co.

8 Teflon Pipe. Haveg Industries, Inc. announces production of Teflon pipe & tubing & Teflon-lined steel pipe. Details on request.

9 Organic Chemicals. New 12-page catalog lists 77 commercially available products with formulas, product descriptions & suggested uses. Pennsylvania Salt Mfg. Co.

10 Dichlorophene. Comprehensive bibliography of literature on Dichlorophene. Contains abstracts of 109 scientific trade articles and 12 patent abstracts. Indexed.

11 Wool Felt Filtration. 10-page technical data sheet on use of wool felt for liquid filtration. American Felt Co.

12 Spirally Cabled Tubing. The Crescent Armored Multitube system protects tubing against mechanical and corrosive injury during & after installation. 10-page brochure from Crescent Insulated Wire & Cable Co.

14 Vinyl Acetate. Physical properties, grades, specifications & handling, polymerization & chemical reactions. 20-page bulletin from Air Reduction Chemical Co.

15 Nitrogen Solutions Handbook. 48-page handbook published by Nitrogen Division, Allied Chemical & Dye Corp., gives chemical and physical properties of solutions, granulation and formulation information. Numerous formulas and conversion factors.

16 Thermoplastic Hydrocarbon Resins. Physical & electrical properties, test & strain data, test recipes, product formulations. Twenty-page technical bulletin from Velsicol Chemical Corp.

17 Refractories. Properties & applications of a variety of refractory materials are described in an 8-page bulletin from the Carborundum Co. Special discussion of heat resistance, including chart of expansion & contraction at constant load.

18 Polymerized Fatty Acid. 20-page brochure giving specifications, characteristics, & applications of Empol 1022 polymerized fatty acid. Many charts & tables & extensive bibliography. Emery Industries, Inc.

19 Non-woven Dacron Felts. Du Pont brochure giving properties of nonwoven Dacron felts. Tables & charts on tensile strength, thermal conductivity, coefficient of friction, chemical resistance, resilience, heat resistance, absorption capacity, etc.

20 Protective Coatings. Practical work manual presenting useful painting data in form of charts, tables, diagrams & illustrations. U. S. Stoneware.

21 Titanium, Zirconium, Tantalum. Tabular data on acid corrosion resistance of tantalum, columbium, zirconium & titanium are contained in bulletin from Fansteel Metallurgical Corp. Also information on application of tantalum in process equipment.

22 Polyethylene Pipe. Non-toxic, pressure-proved, general-purpose flexible plastic pipe announced by American Hard Rubber Co. Low cost, flexibility, ease and speed of installation. Applicable to industrial piping systems handling water or corrosive solutions at normal temperatures.

23 Polyester Dyes. New line of dyes created specifically for polyester fibers announced by Eastman Chemical Products, Inc.

24 Chemical Resistant Coatings. Illustrated bulletin describes three classes of

(Continued on page 74)

***√ CHECK** your Data Service requests on the handy postcard on page 67 to*

***▶ GET** up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

DEVELOPMENTS OF THE MONTH *(Continued)*

115 Adhesive Trial Kit. U. S. Stoneware offers a trial kit containing instructions &

an adequate supply of the principal Tygoweld adhesives for experimentation & evaluation in the customer's plant. Price of the kit is $8.00.

These thermosetting adhesives based on alloyed epoxy resins, are now being produced as a paste, mat, powder, rod, liquid & gel. Use of one or combinations of these six forms offers a wide range of possibilities in solving many bonding problems. It permits adaption of bonding techniques to large or small production, intricate shapes, as well as improvement in design & construction.

Tygoweld employs moderate cure temperatures, practical cure times, & low bonding pressures to produce strong, durable welds between similar and dissimilar materials such as ferrous & nonferrous metals, ceramics & glass, sintered metals & metallic oxides, thermosetting plastics, wood, paper, plaster, concrete, composition board & others.

(Continued on page 74)

A TRIO FOR PROCESSING PROBLEMS

CONKEY CRYSTALLIZERS, EVAPORATORS AND FILTERS

This is the *trio* that will remedy your crystallizing, evaporating or filtering problems. All three are built to the rugged Conkey design, fabricated in Chicago Bridge & Iron Company's four strategically located shops.

If your plant has a filtering, evaporating or crystallizing problem, write our nearest office. A Conkey engineer will be happy to assist with information, estimates or quotations.

Top: Conkey all nickel construction Triple Effect Evaporator producing 50 per cent caustic liquor.

Above: Conkey Triple Effect Vacuum Crystallizer producing ammonium sulphate.

Left: Conkey Rotary Hopper Dewaterer in service dewatering abrasive grains.

CHICAGO BRIDGE & IRON COMPANY

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.

CONKEY EQUIPMENT

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
Los Angeles • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • Tulsa

materials-(Cont.)

chemical-resistant organic coatings: 1. Ucilon coating systems applied like paint for general corrosion control, 2. Unichrome plastisol compounds for heavy-duty service, 3. Unichrome special materials for lining steel drums & tanks. Metal & Thermit Corp.

25 Isocyanates. Two new isocyanates, never before offered in semi-commercial quantities, are now available from the Carwin Co. Bulletin gives properties & applications of polyaryl polyisocyanate & n-butylisocyanate.

26 Bondable Teflon. The Dixon Corp. offers literature on the bondability of Teflon & Rulon (modified Teflon). These materials are now surface-treated, which permits bonding to metals, wood, other plastics, cloth, web belts, etc.

27 Air-setting Cement. Bulletin on uses and application of Crystolon RC 2351 refractory cement. Norton Co.

28 Heat-resistant Rubber. Dow Corning fluoro-silicone rubber has high resistance to swelling with jet fuels, gasoline, aromatic oils and solvents.

29 Irradiated polyethylene. 12-page technical report on chemical and thermal properties of Irrathene (R). General Electric.

30 Ceramic Magnet. New non-metallic, electrically non-conductive ceramic magnetic material announced by North American Philips Co. Technical data sheet.

31 Glycerine. Illustrated booklet (17-page) giving chemical, physical properties, industrial applications. Glycerine Producers Ass.

32 Coating Resins. 48-page technical data manual. American Cyanamid Co.

33 Peroxygen Chemicals. Complete bulletin list available from Food Machinery & Chemical Corp.

34 Monomers. Folder gives physical properties & suggested uses for 36 different monomers produced by Carbide & Carbon.

35 Fluorocarbon products. M. W. Kellogg brochure gives forms, properties & uses—from plastic resins to acids and dielectric fluids.

36 Phosphonitrilic Chloride. Data sheet with properties and uses of refined & technical grade. Millmaster Chemical Corp.

*√ **CHECK** your Data Service requests on the handy postcard on page 67 to*

*▶ **GET** up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

37 Phenol-C^{14}. Available at specific activity of one millicurie per millimole. Three package sizes. Over 150 other radioactive carbon compounds. Nuclear Instrument & Chemical Corp.

38 Industrial Chemicals. Complete line of Olin-Mathieson chemicals described in 20-page booklet.

39 Synthetic Elastomers. "Lightning Selector" to make rapid, accurate choice of proper silicone compound or gum. General Electric.

40 Methyl Linoleates. Chemical analysis, characteristics, contained in new brochure from Pacific Vegetable Corp.

41 Petroleum Sulfonates. 6-page technical data bulletin describes four new segregated petroleum sulfonates. Pennsylvania Refining Co.

42 Silicone Oil. DiEthyl Silicone Oil, L-41, is now available on a commercial scale. Union Carbide & Carbon.

services-

43 Engineering Drawings-Acid Brick. Details of acid-proof masonry construction for six typical installations. Drawings available from Pennsylvania Salt Mfg. Co.

44 Basic Process Design. Brochure from Industrial Process Engineers gives basic design considerations on plants for manufacture of alkyd resins, fatty alcohols, phenolic resins, maleic anhydride & for fatty acid hydrogenation. Typical flow sheets, piping layouts, equipment design & installation are included.

45 Plant Layout. Visual Plant Layouts, Inc. offers extensive literature on new 3-dimensional plant layout methods.

46 Process Plants & Equipment. 43-page brochure from Link-Belt Co. covers research facilities, products & equipment & technical literature.

47 Nitric Acid Plants. Bulletin describing latest design by Fluor Corp. Flow diagram & material requirements.

equipment-

48 Specifications & Applications Guide. Babcock & Wilcox Co. offers 4-page folder listing specifications & applications of tubing, fittings & flanges in various grades of steel.

49 Polyethylene Pillows. Newly-developed polyethylene pillows are claimed to reduce evaporation of liquids in open vessels by up to 70%. Catalog sheet available with details. American Agile Corp.

50 Traveling Pan Filter. Two-page leaflet from Dorr-Oliver, Inc. describes unique features, operation, advantages & sizes of new type of filter. Typical layout diagram included.

51 Pumps. Tables of capacities on metering and proportioning pumps. 16-page catalog from Hills-McCanna.

52 Automatic Regulators. 8-page condensed catalog of automatic pressure, temperature and level control valves for automatic process control available from Atlas Valve Co. This brochure compiled specifi-

(Continued on page 76)

DEVELOPMENTS OF THE MONTH *(Continued)*

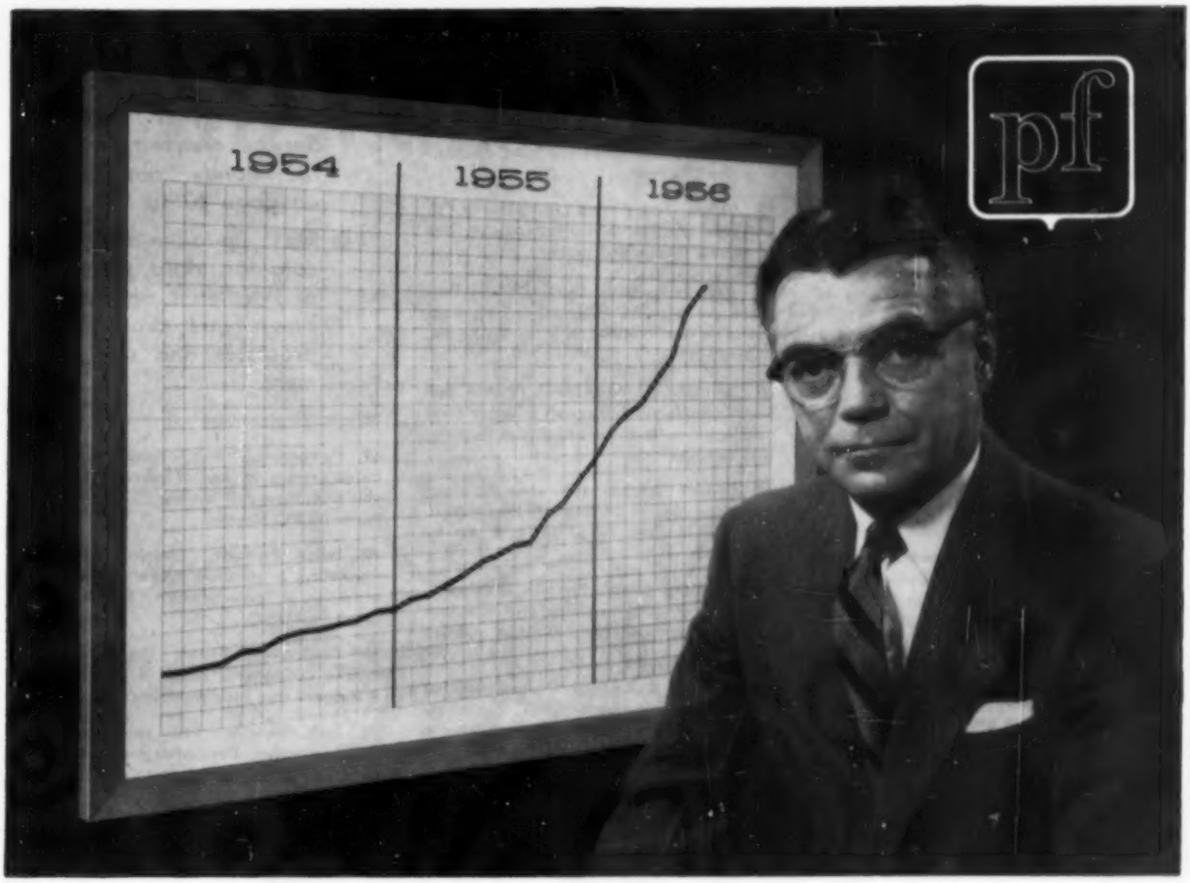
116 Corrosion Meter. The Corrosometer, product of the Crest Instrument Co., is said to be the first successful means of measuring & recording corrosion. Principle is simple. Corrosion converts metal into nonmetal. Electrical resistance across a piece of metal thus increases as corrosion proceeds on its surface. Specially designed meter circuit in the Corrosometer gives readings directly in terms of micro-inches of corrosion.

Advantanges claimed for this method are:

1. Rapid & direct measurement. Individual measurement requires only about 30 seconds.
2. Continuous record.
3. Convenient measurements in any location. Several hundred feet of extension cable may be used.
4. No shut-down to retrieve specimens.

Complete technical bulletin available.

(Continued on page 76)



Edward A. Ulrich, V. P. & Gen. Mgr. of Process Filters, Inc., reports:

"Facts behind the sensational rise in Process Filter installations"

"Our sales curve continues to move upward on a sharp angle, but it gives you only part of the story.

"Companies now owning Process Filters include many of the most respected names in industry. They're located in every section of the country from Parlin, New Jersey to Alhambra, California . . . and they're using our equipment to meet a multitude of requirements from filtering cumic acid to "green salt" and from cyanide slimes to molten sulfur.

"In the past few years, Process Filters, Inc. has introduced many innovations in filtration and has come up with dozens of new and practical solutions to increase production rates, ease of operation and efficiency.

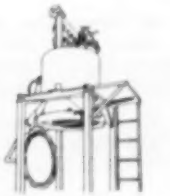
"The growth of Process Filters, Inc. reflects its ability to provide successful filtration in greatly diversified applications. It's a good reason why you can expect PF to design and build pressure leaf filters that will prove most successful for you, too!

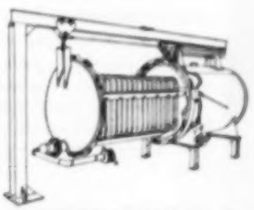
"We'd like to tell you more about Process Filters and what they can do in your plant. Please write."

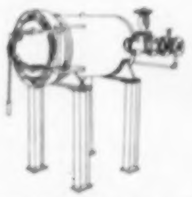
ILLUSTRATED BULLETINS MAILED ON REQUEST

PROCESS FILTERS, INC. (A subsidiary of BOWSER, Inc.)
1805 Elmwood Ave., Buffalo 7, N. Y.


VERTICAL LEAF FILTERS


VERTICAL BATCH FILTERS


HORIZONTAL LEAF FILTERS


HORIZONTAL BATCH FILTERS

COMING ATTRACTIONS

New Units to be Announced Soon

equipment- *(Continued)*

cally for operating and design engineers & production men.

53 Level Control. Automation Products, Inc. offers new level control device employing different principle. Output of generator energizes relay to control operation of any type of electrical equipment. Accurate to .01 in.

54 Ball & Pebble Mill. The Futura Mill combines maximum efficiency & lower cost with enhanced operator convenience. Illustrated brochure from Patterson Foundry & Machine Co. gives details of improved ball and pebble mill. Advantages claimed are accurate water control, 20% greater jacket area, and higher water velocity for faster heat transfer.

55 Instrument Literature Index. Minneapolis-Honeywell Regulator Co. has prepared an index of literature on technology & applications of a wide range of instruments.

56 Gage Glass Cleaning Rod. A new type of rod developed by the Jerguson Gage & Valve Co. permits a good cleaning job with little or no effort. Description and specifications will be sent.

57 Vapor Recovery Systems. 48-page technical bulletin with many charts and conversion factor tables. Vapor Recovery Systems Co.

58 Dewatering Equipment. Stearns-Roger offers bulletin on new line of dewatering presses and dryers.

59 Speed Reducers. Versatile line of helical speed reducers for heavy-duty, low-cost gear drives. Literature from Philadelphia Gear Works.

60 Valves—Pipe Fittings. Parks-Cramer Co. will send 26-page catalog on complete line of valves, fittings and piping.

61 Heat Exchangers. Sectional Aero Heat Exchanger provides industrial cooling without large water supply. Niagara Blower Co. Bulletin.

62 Industrial Thermometers. Product bulletin from Manning, Maxwell & Moore gives specifications and dimensions of bi-metal dial thermometers.

63 Turbine Pumps. Full color brochure shows sections of Verti-Line turbine pumps, enclosed lineshaft type. Layne & Bowler Pump Co.

64 Sampling Valves. Packless, self-closing, sliding-gate sampling valve for hazardous and corrosive liquids. Bulletin, Jordan Corp.

65 Vacuum & Pressure Gauges. Highest accuracy, stable performance, rapid response, long life. Hastings-Raydist. Bulletin.

66 Tank Seals. Catalog & Data Book on "Tubeseal" system for floating-roof storage tanks. Hammond Iron Works.

67 Koroseal Pipe. 8-page illustrated brochure describes applications & properties of high impact rigid Koroseal pipe, fittings & valves. B. F. Goodrich.

68 Kiln-Preheater. Technical article describes installation of preheater in modernization of cement plants. Fuller Co.

√ **CHECK** *your Data Service requests on the handy postcard on page 67 to*

▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

69 Flowmeters. Fischer & Porter offer illustrated catalog on line of multi-stage, variable-area Flowrator meters. 5 to 100,000 lb./hr., 0.5% accuracy.

70 Teflon Products. Chemical, thermal, mechanical & electrical properties of complete line of Teflon products. Bulletin from Crane Packing Co.

71 Conductivity Gauge. Hastings-Raydist thermal conductivity gauge is more stable & accurate than resistance type instruments.

72 Leak Detector. Low cost, portable, highly sensitive. Descriptive brochure from Consolidated Electrodynamics Corp.

73 Hydraulic Filter Press Closer. The Hydro-lock converts any mechanically operated plate & frame filter press to hydraulic closing. Biach Industries. Bulletin.

74 Control Panels. 16-page brochure from Bailey Meter Co. gives specifications & design features of line of standardized instrument & control panels.

75 Polyethylene Equipment. Centrifugally cast polyethylene tubing finds many applications in corrosive service. Literature from American Agile Corp.

76 Mass Spectrometers. Design & performance characteristics. 16-page bulletin. Consolidated Electrodynamics Corp.

77 Electronic Instruments. Data Sheet gives concise information on electronic potentiometer-type indicators, recorders & controllers. Leeds & Northrup.

78 Vacuum Dryer. Rota-Cone dryer now available in steel, stainless, aluminum, monel & bronze. Capacities from 1 to 325 cubic feet. Paul O. Abbe, Inc.

79 Rotary Filters. Outstanding features, design, operation, sizes & capacities of the Oliver horizontal rotary filter. Dorr-Oliver. Bulletin.

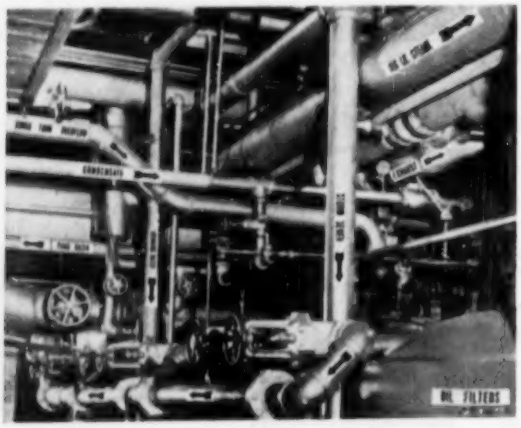
80 Ribbon Type Mixers. Eight sizes of ribbon type mixers, available with choice of 6 agitator types. Brochure from Cincinnati Hildebrand Co.

81 Heat Exchangers. Table of dimensions, type designation table, finside coefficient & finside pressure-drop charts. Alco Products.

(Continued on page 78)

DEVELOPMENTS OF THE MONTH *(Continued)*

117 Pipe Marking System—Free Kit. With pipe indentification standardized, tracing pipe lines is quick & sure through different rooms, departments & buildings. Maintenance down-time is reduced, operating errors minimized & plant safety improved.



Brady Perma-Code Pipe Markers come in stock heights to fit any size pipe. They are made of all-temperature vinyl cloth with a heavy-duty all-temperature adhesive, and in addition they are silicone-plastic over-coated for long life.

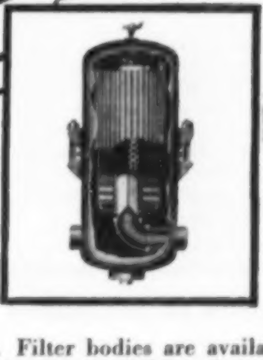
Markers are guaranteed to stick to pipes for a minimum of two years. Bold, black letters on ASA Standard A-13 background colors identify pipe contents with both color & legend. Matching stock directional arrows indicate flow direction of pipe contents.

Free kit is available including planning guide, cost comparison & safety information, application photos, free testing samples & stock list. W. H. Brady Co.

(Continued on page 78)

KEEP IT CLEAN...

by Phil Tration



MODEL ELS LIQUID FILTER

The uses for Dollinger liquid filters are truly "elephantine"... any liquid (you name it) can be efficiently and economically handled by these filters. The world wide use of Dollinger Filters on thousands of liquids is proof of their adaptability to every requirement.

All known filtering materials can be used in the Dollinger Design for any problem regardless of temperature, pressure, or corrosion factors. Filter bodies are available in steel, stainless, monel, herculoy and other non-corrosive materials. Construction can be according to ASME or API Code specifications. Let us know your requirements. Dollinger Corporation, 79 Centre Park, Rochester 3, N. Y.

SEND *for 12-page Bulletin 300 which gives liquid filter engineering and performance data plus other helpful information.*

DOLLINGER STAYNEW FILTERS

LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS
ELECTROSTATIC FILTERS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS
VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS • HIGH PRESSURE FILTERS
AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

equipment-*(Continued)*

82 Small Diameter Tubing. Data memorandum lists analyses of 121 metals & alloys. Superior Tube Co.

83 Polyethylene Pipe. Specifications, technical properties. Tables & charts. Bulletin. American Hard Rubber Co.

84 Infrared Analyzer. The Beckman L/B Infrared Analyzer Model 21 can now be furnished with explosion & corrosion proof accessories. Literature.

85 Tubular Process Heaters. 12-page technical paper "Effect of Convection Heat in Radiant Sections of Tubular Process Heaters." Charts & diagrams. Petro-Chem Development Co.

86 Slurry Mixer. Design variations, capacities, sizes, physical characteristics of Dorr slurry mixers. Bulletin from Dorr-Oliver.

87 Heat Exchangers. Specifications & dimensions for 4 styles of Platecoil heat exchangers. Conversion table. Bulletin. Tranter Manufacturing.

88 Shut-off Valves. Coppus Engineering offers a wide range of sentry valves actuated by excess flow, overpressure, overtemperature. Also solenoid types. Bulletin.

89 Scanning Spectrometer System. Tracerlab's Stepwise Scanning Spectrometer system obtains & records automatically data normally required for analysis of nuclear radiation spectra.

90 High-Vacuum Still. High-vacuum, brush-type still, product of Consolidated Electrodynamics, has extremely high fractionating power. Data sheet.

91 Electro-Caloric Flowmeter. Catalog from Industrial Development Laboratories describes function, construction & operation of the Laub Flowmeter.

92 Bagging Scale. "Weighblender" automatic bagging scale specially designed for pre-mix concrete offered by Richardson Scale Co. Bulletin.

93 Valves. Hex Valve Co. offers valves of new design. Strong, safe & compact, they can be repaired under pressure. Bulletin.

94 Centrifugal Pumps. Ampco Metal, Inc. has added a complete line of centrifugal pumps constructed of 316 stainless steel. Literature.

95 Thermocouples. 14-page bulletin from Thermo Electric Co. Includes selector chart for choosing correct type of miniature protected thermocouple.

A.I.Ch.E. MEMBERSHIP

Brochure—"Know Your Institute"—tells objective aim and benefits to chemical engineers who join this nation-wide organization, includes membership blank. Circle number 119 on Data Post Card.

96 Mixer-Unloader. Six-page data sheet describes new Allen-Sherman-Hoff continuous mixer-loader. Line diagrams & dimensional & construction tables.

97 Fluid Drive. Size 126 Type T Gyrol Fluid Drive is designed for general industrial application. Bulletin from American Blower Corp. gives drawings & rating charts.

98 Pressure Regeneration Dryers. For large volumes of compressed air or gas. Steam or electric regeneration. Automatic, semi-automatic, or manual controls. Data sheet from Industrol Corp.

√ **CHECK** *your Data Service requests on the handy postcard on page 67 to*

▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

99 Moisture Controller. Continuous automatic moisture meter measures, indicates, records, controls. Mechanical & Electronic Prod. Div., Quaker Oats Co. Bulletin.

100 Electrical Heating Units. Catalog contains information & design selection charts on all types of electrical units & devices. Westinghouse Electric.

101 Pipe Fittings. 28-page catalog on forged steel pipe fittings. Dimensional, engineering & application data in simplified charts. H. K. Porter Co.

102 Recording Potentiometers. High-speed self-balancing recording potentiometers for use with analog-to-digital conversion devices are announced by The Bristol Co. Literature.

103 Steam Condensers. Condensers, evaporators, deaerators, converters, feedwater heaters, steam jet air ejectors. Bulletin from Condenser Service & Engineering Co.

104 Load Cell. Off-center loading stability is feature of load cell offered by A. H. Emery Co. for bin, tank & hopper weighing systems. Literature.

105 Drain or Sampling Valve. No. 23 Drain or Sampling Valve, product of Jerguson Gage & Valve Co., is now available in standard sizes of 1¼", 1½", 2" N.P.T. Literature.

106 Positive Displacement Pump. Low capacity positive displacement pump in corrosion-resistant Hastelloy C now available from Eco Engineering Co. Capacity to 10 gpm, viscosity to 900 SSU, temperatures to 250° F. Literature.

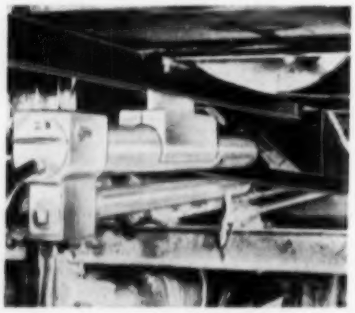
107 Filter Presses. Operating procedures, engineering data, specification table, illustrations in bulletin from Brosites Products Corp.

108 Chlorine Detector. The Wallace & Tiernan Solvay Chlorine Detector monitors chlorine concentrations down to 3 ppm. Literature.

109 Turbo Dryer-Cooler. Simultaneous, uniform low temperature drying & cooling of free flowing, granular or powdery solids. Steel, aluminum or stainless construction. Literature from Wyssmont Co.

DEVELOPMENTS OF THE MONTH *(Continued)*

118 Thickness Gauge. The Betameter, an instrument employing beta radiation for extremely accurate measurement of mass per unit area, is used to measure & control sheet thickness, basic weight, coatings, etc.



(Photo shows application in manufacture of roofing material). It is particularly adapted to measurements which cannot be made with conventional equipment since the instrument does not physically contact the materials being measured.

In the measurement of sheets with the Betameter, a sealed source emitting beta rays is mounted on one side of the sheet, a radiation detector on the opposite side. The current generated in the detector is correlated directly with the sheet mass & so with the sheet thickness. Scales can be set up to read in any desired units.

Decay of the radioactive source, effects of air pressure & temperature are all cancelled out continuously & automatically with no need for standardization interruptions.

Complete information available from Isotope Products, Inc.

(Advertisement)

Corrosioneering News

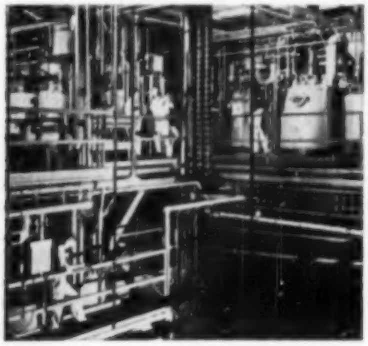
Quick facts about the services and equipment available to help you reduce corrosion and processing costs.

Published by The Pfaudler Co., Rochester, N.Y., U.S.A.

Why Pfizer chooses Pfaudler equipment to help produce lifesaving antibiotics

Chas. Pfizer & Co., Inc., uses Pfaudler glassed steel equipment to make Terramycin and Tetracyn – as well as many other antibiotics. If product purity is as important to you as it is to Pfizer, you too can rely on Pfaudler glassed steel.

Because the conditions for producing antibiotics are so exacting, pharmaceutical plants are equipped with



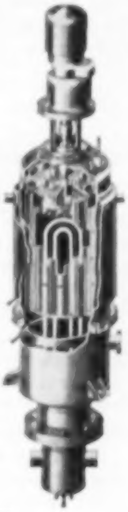
only top-quality material. Pfizer relies upon Pfaudler glassed steel reactors not only to assure the purity of their product but to maintain high yield as well. Several of these Pfaudler reaction kettles appear in the above picture of Pfizer's antibiotic recovery plant.

Only hard smooth glass comes into contact with your product if it's processed in a vessel like these. There's no chance of contamination –and you can clean glassed steel easier and quicker than any other material. Every batch is as pure as the one before.

If consistent yield and absolute purity are as essential to *your* process as they are to the makers of antibiotics, you should consider glassed steel equipment, resistant to both acid and alkaline solutions. To learn more about Pfaudler glassed steel–and alloy–products, send for the "Buyer's Guide." The coupon is for your convenience.

Unique new evaporator

You can test your own product–and in that way uncover areas of greater profit–with Pfaudler's new wiped-film evaporator for vacuum distillation.



A *floating carbon blade* cleanly wipes the peripheral evaporating surface to promote a very thin film and turbulence –creating higher heat transfer rates and faster evaporation.

Two models are available now: a two-inch laboratory evaporator and a 12-inch pilot plant unit. For more information, contact your Pfaudler representative or write for our bulletin.

How Armour provides on-the-spot technical aid

Recently Armour Laboratories opened new pilot plant facilities in Kankakee, Illinois, which will be used to develop new processing techniques for pharmaceuticals.

In order to provide on-the-spot technical assistance, Armour uses only the very latest equipment and techniques. A typical feature is a novel six-paneled service board which gives the pilot plant an unusual flexibility. In the picture (above) an operator is connecting a Pfaudler "P" series glassed steel reactor to one of the panels for vacuum and refrigeration.

Such services as water, air, steam, vacuum, and propylene glycol refrigerant may be hooked up to the portable equipment at the laboratory. Armour uses the Pfaudler glassed steel reaction kettle as a portable extraction vessel.

You can learn more about the Pfaudler "P" series of small process units by sending for Bulletin 881. Mail the coupon today.

THE PFAUDLER CO., Dept. CEP-10, Rochester 3, N. Y.

Please send data on ☐ Buyer's Guide

☐ Pilot plant equipment ☐ Wiped film evaporator

Name

Title

Company

Address

City Zone State

A Pittsburgh Meeting Report

O. R. DECISION AIDING

Part of the capacity audience at the Pittsburgh Operations Research Symposium.

A new scientific aid to management decision-making comes into focus for the chemical engineer. Operations Research achieves the assembly of all possible choices from which management can select its course of action. How Operations Researchers get their results, and how you, as a chemical engineer, can play a vital part—possibly advancing your career in many ways—is told by a group of highly experienced workers in the field.

They came in numbers too large for the capacity of the room. They stood, or sat on the floor. The reason: chemical engineers' dramatic interest in scientific aids to management, otherwise known as "Operations Research." The occasion was George Creelman's symposium, "Scientific Aids to Management—Chemical Engineering Operations Research," at the Pittsburgh National Meeting of A.I.Ch.E. Sept. 10.

HOW TO GET YOUR COMPANY STARTED IN O.R.

1. Make certain that, by one means or another, your top people are sold on OR.
2. Train, or acquire the services of, one or more individuals schooled in OR approach and methodology.
3. Assemble an OR group, making sure that you include your top people as well as those who will have to administer the ultimate decisions.
4. Tackle existing problems that everyone admits are important.
5. Submit a written report to management, defining the choices open for decision, weighted as to the probable results from any given course of action.
6. Expect to achieve, as a bonus, higher motivation and better understanding on the part of participating members of the group.

—G. D. Creelman

What Is Operations Research?

Variously described as "self-conscious methodology" and "scientific solving of management problems," Operations Research, using a combination of mathematical and social science techniques, serves primarily to define alternate choices for decision making to a more thorough degree than is usually possible. This was the consensus of the group of OR specialists who addressed the symposium.

OR decision recommendations are frequently derived from electronic computer and modern data processing methods, together with the practice of group psychology.

Team Approach

Operations Research, being aimed at problems which arise at a level where functional operations come together in a company, must of necessity cut through all departmental boundaries. Best place to start an OR function is at the top. Typical OR teams are made up of individuals with widely divergent specialties—executives, researchers, engineers, mathematicians, personnel workers, psychologists.

Operations researchers recommend that a company going into OR organize a permanent team which may be supplemented by additional specialists when they can contribute to the project under consideration. They emphasize, further, that a team should always include at least one representative of the groups which will later have the responsibility of putting the decisions into actual operation. Such a policy facilitates acceptance of the team's recommendations.

The same reasoning lies behind the stipulation that a team should include management people, one or more OR people, as well as technical specialists. It is considered that most of the latter should be intracompany: outside specialists should be called on only to provide skills which are not available within the company.

Accounting for the Future

An OR-based accounting system should be able to prepare figures for the control of the future rather than merely for the reconstruction of the past. So said R. L. Ackoff, Case Institute. To make this possible, powerful new mathematical tools are available which permit calculation of the effect of any one proposed executive decision on the operation as a whole. This is done by the simulation of an industrial situation by mathematical equations. By suitable manipulation of these equations the effect of any one single variable can then be isolated and studied.

Ackoff listed seven types of problem

(*Continued on page* 82)

(Advertisement)

LENGTH OF FILTER CYCLES

Filteraids are commonly rated as to effectiveness in terms of flow rate and clarity. For many filter press applications, however, cycle length is equally important. This is increasingly true as labor rates rise each year, so that the cost of press room labor becomes a larger and larger burden on the operation.

Cycle length is generally limited by declining flow rate towards the end of the cycle. In certain systems where high specific resistance cakes are formed, it may be necessary to terminate the cycle before the press is filled in order to maintain an average rate high enough to meet production demands. For most systems, however, cycle length can be extended to minimize labor costs. Three factors are of prime importance.

First, select the proper grade of filteraid. Filtration rates may be increased several-fold by employing the filteraid whose particle size range matches the filterable solids being removed. This insures freedom from migration of fines through the cake to blind the cloth and yields maximum filtrate volume per press cycle.

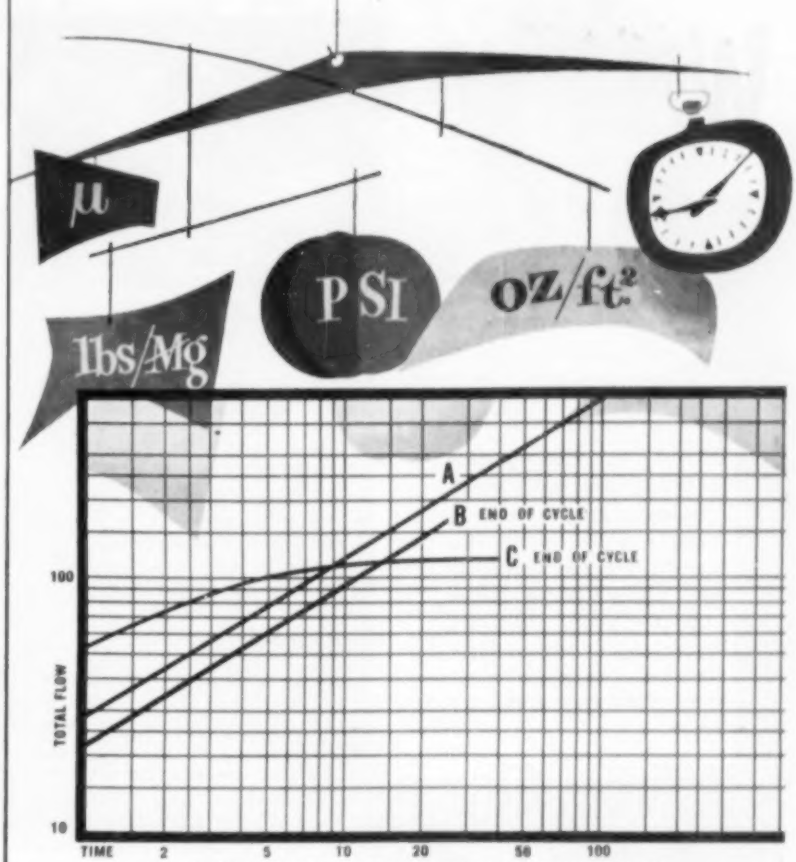
Second, select a filteraid of high quality. It is generally known that superior air classification is the heart of the filteraid manufacturing process. Few people realize that diatomite filteraid plants represent investments of millions of dollars, and include exceedingly complex air classifier circuits. In our modern plant at Lompoc, California, for example, the product passes successively through fourteen cyclone separators. These are all of highly specialized design, based upon twenty-five years of experience, and are not available to industry from the suppliers of standard dust collector equipment. High quality filteraids hold flow rate decrease to the theoretical 0.5 slope. Poor quality filteraids, though often possessing high initial flow rate (due to coarseness) tend to "tail off," as the cycle progresses.

The third important factor in extending press cycle length is to use the optimum percentage of filteraid. In many instances cycle length is limited through the use of excessive amounts of filteraid, thus filling the press prematurely and terminating the cycle. On the contrary, some customers use insufficient filteraid to maintain the desirable 0.5 slope.

In conclusion, filteraid technology is neither mysterious nor "arty." The selection of the best filteraid for most effective filtration can be established by carefully controlled tests. Claims for super performance should be viewed with suspicion, particularly unless claims are backed up by reliable data obtained either by technically sound laboratory tests (not slanted either deliberately or inadvertently through the selection of improper test conditions) or by actual plant scale test runs. Dicalite filtration engineers are fully competent to render this service. Their assistance is freely available. Don't fail to take advantage of this to improve your filtration efficiency.

P. W. Leppla, Technical Director

All these must balance...



CHARACTERISTIC PLOTS OF CONSTANT PRESSURE FILTRATION CYCLES

for MOST EFFICIENT FILTRATION

These plot lines, established in actual tests under plant conditions, clearly point up the importance of balancing *all* the filteraid factors – particle size; particle size range and distribution, precoat and body feed requirements. Line A shows the satisfactory flow rate and long cycle length obtained with such balance. Line B shows the result of too much filteraid – lower flowrate and short cycle, due to rapid filling of the cake space in the filter. Line C demonstrates the results of either insufficient filteraid or too coarse a filteraid; note the rapid drop in flow rate and the short cycle caused by solids blinding the filter screen.

For most efficient filtration, Dicalite provides a complete range of dependable, uniform filteraids to meet the requirements of practically any filtration. And Dicalite service engineers, working in your own plant, can help you "balance" your filtrations for highest clarity, optimum throughput and longer cycles.

Dependable GLC GREAT LAKES **Dicalite**® DIATOMACEOUS MATERIALS

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OPERATIONS RESEARCH

(Continued from page 80)

Chemical Engineers' interest in O. R. guaranteed rapt attention for the panel of speakers.

which have proved to be particularly amenable to this sort of attack:

1. **Inventory levels**
2. **Allocations**
3. **Waiting time factors**
4. **Work station schedules**
5. **Replacement versus maintenance**
6. **Competitive relationships**
7. **Information requirements.**

Important Tool

The use of linear programming as a mathematical tool for the analysis of practical industrial problems has become well established in recent years. According to W. W. Cooper of Carnegie Institute and A. Charnes of Purdue, this technique can be applied to such diverse OR problems as determining production programs, loading machines, setting market quotas, and determining executive salaries.

Psychologists' Contribution

The important role which the trained social scientist can play in modern industrial organizations was brought out by R. W. Wallen of Creelman Associates, formerly Associate Professor of Psychology at Western Reserve University. He emphasized that the effectiveness of the OR team depends on its ability to bring out the latent creative thinking of its members. The presence on the team of a psychologist trained in group techniques will help to accomplish this end and will increase the efficiency of the group. In many cases, said motive-conscious Wallen, *what* the team is doing is of less importance than its being made aware of *how* it is tackling the problem.

Is Probability Useful?

Operations researchers often assign probability ratings to variables which are not amenable to rigorous mathematical treatment. But can mathematical meaning be attached to factors which involve human relations; can labor trouble or a client's dissatisfaction be put into equations? Yes, say OR experts, who point out that any formulation, whatever the probable degree of error, is better than no analysis at all. No, say others, who insist that putting such factors into mathematical calculations can only result in vitiating completely the validity of the results. More experience will have to be piled up before this question can be satisfactorily resolved.

Whole vs. Parts

Criticism has been directed at OR on the ground that many of the methods it employs have been in use for many years under other names. However, according to the OR people, the whole is often greater than the sum of its parts. Bringing together all aspects of a given problem into one formulation, new concepts and insights are often gained which would not have been apparent if the situation had been regarded piecemeal.

Prerequisites for Practical Application

Prerequisites for successful results with OR are, according to T. M. Ware, International Minerals and Chemical:

1. **The team approach**
2. **Judicious use of outside consultants**
3. **Clear objectives**
4. **Organizational maturity**
5. **Staff cooperation**
6. **Correct interpretation of results**
7. **Vigorous follow-through by management.**

Besides International Minerals, several other large companies have Operations Research groups at work at various organizational levels.

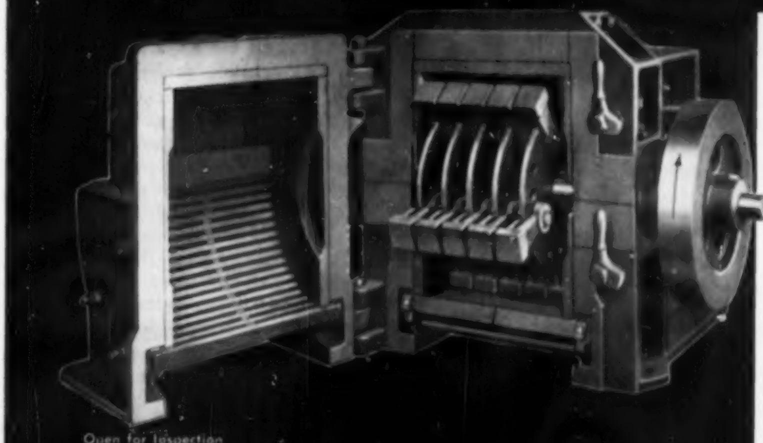
The Chemical Engineer's Role

Here, in Operations Research, is a way in which the chemical engineer can apply his scientific training to general management affairs. Besides the inevitable broadening of his point of view, the field would seem to offer definite opportunities for the enterprising engineer to advance himself within the organization of his particular company.

The chemical engineer, by the very nature of his work, is trained to consider many aspects of research and production problems. The recent successful application of the concept of unit operations to the chemical industry is sufficient evidence of the ability of the chemical engineer to isolate variables, to categorize fields of operation, and to integrate all phases into a smoothly running whole. It remains for him to extend this same type of thinking to embrace management functions as well as purely technical considerations.

"Two Minutes Daily Solved Our Tough Grinding Problem"

Says W. Carleton Merrill, Manager, Protein Division, Jas. F. Morse Co., Boston, Mass.



Open for Inspection

Sturtevant Swing-Sledge Mills (illustrated) crush moderately hard materials at rates up to 70 tph; Hinged-Hammer Pulverizers crush softer materials at rates up to 30 tph. Reductions on both mills up to 20 mesh. **Request Sturtevant Bulletin No. 084.**

Engineered to Save Downtime, Keep Production on Schedule

One man can swing open a Sturtevant Swing-Sledge Mill or Hinged-Hammer Pulverizer in less than one minute — for inspection, clean-out or maintenance — thanks to Sturtevant's unique "Open-Door" design.

Costly downtime is cut to a minimum, production kept on schedule — **even when the unexpected happens.** Little wonder that users say: "Because of their rugged construction and "One Man, One Minute" accessibility, Sturtevant machines give us **lower** operating costs over **more** years."

STURTEVANT "OPEN-DOOR" DESIGN MAKES MAINTENANCE A CINCH, INSURES OPERATING EFFICIENCY

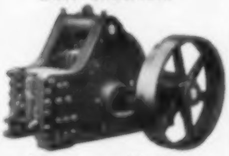
"We wanted 100 per cent discharge area from our grates," Merrill of the Morse Co. reports. "But cake tankage — broken bone pieces and trimmings of meat and fat — can clog up any grate if all the grease isn't pressed out. In two minutes at the end of the day we can open our Sturtevant Swing-Sledge Mill for inspection, clean it if necessary, and button it up for the next day's production."

If you grind anything as unpredictable as cakes of dry rendered tankage — like the Morse Company does — or desire low-downtime for clean-outs and emergency maintenance, you'll want the "One Man, One Minute" accessibility plus rugged construction that has been engineered into Sturtevant crushing and grinding machinery.

Write today describing your problem. Please include information on materials, process and desired capacity.

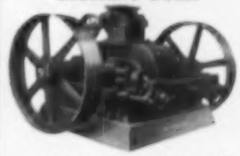
Address: Sturtevant Mill Co., 135 Clayton Street, Boston 22, Mass.

JAW CRUSHERS



Reduce coarse (5 in. largest model) to fine (1/8 in.) smallest model. Eight models range from 2 x 6 in. jaw opening (lab model) to 12 x 26 in. Capacities to 30 tph. All except two smaller sizes operate on double cam principle — crush twice per energy unit. *Request Bulletin No. 062.*

CRUSHING ROLLS



Reduce soft to hard 2 in. and smaller materials to from 12 to 20 mesh with minimum fines. Eight sizes, with rolls from 8 x 5 in. to 38 x 20 in.; rates to 87 tph. Three types — Balanced Rolls have automatic adjustment in operation; Recommended for 3 to 1 reduction. *Request Bulletin No. 065.*

ALL STURTEVANT MACHINES ARE DESIGNED TO OPERATE ADVANTAGEOUSLY IN "UNITS"

ROTARY FINE CRUSHERS

Five models reduce 3 to 8 in. soft to moderately hard materials down to 1/8 to 1 1/4 in. sizes. Capacities up to 30 tph. No clogging; even product flow. Smallest model has 6 x 18 in. hopper opening, largest has 10 x 30 in. *Write for Bulletin No. 073.*

RING ROLL MILLS

Reduce hard or soft 1 1/2 in. and smaller sized material to from 6 to 200 mesh. Grind only — no screens. Capacities of 3 models range up to 18 tph, depending on model, material. Ring diameters and faces 24 x 7 in.; 45 x 8 in.; 44 x 14 in. *Request Bulletin No. 079.*

STURTEVANT

Dry Processing Equipment

The "OPEN-DOOR" to lower operating costs over more years

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BLENDERS • GRANULATORS • CONVEYORS • ELEVATORS

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"Kerodex"® spreads on easily and acts like a glove that is invisible yet strong and flexible. Does not smear. Does not affect materials handled nor is it affected by them. Available in two types. For full information write to Ayerst Laboratories, 22 East 40th Street, New York 16, N. Y. 5670

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SPRAY ENGINEERING COMPANY

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INDUSTRIAL NEWS

STANDARD OF INDIANA LICENSES SPENCER TO MAKE POLYPROPYLENE, LOW PRESSURE POLYETHYLENE

Spencer Chemical will immediately begin construction work on a facility to produce semi-commercial quantities of low-pressure polyethylene and polypropylene under license from Standard Oil Co. of Indiana.

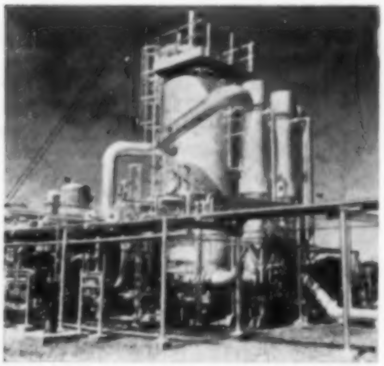
Standard of Indiana, first company to be granted U. S. patents on a commercially feasible process for making high density polyethylene, has its low-pressure process protected by more than 20 issued patents, as well as a number of pending applications, covering polyethylene, polypropylene, and copolymers of ethylene and propylene.

Two of the foremost companies in the heat exchanger industry in Europe and America have joined to form a new American company. The new company, formed to produce and market the unique Schack Recuperator, is the Griscom-Russell-Schack Co. The American parent is Griscom-Russell, a subsidiary of General Precision Equipment Co., and the European is the Schack Rekuperator Co., Dusseldorf, Germany.

The Schack Recuperator, which has achieved prominence in Europe over the last 30 years due to unique engineering features, is a metallic shell and tube heat exchanger. Used predominantly in the iron and steel undustry, it has considerable application in chemical and non-ferrous manufacturing processes. It transfers normally waste flue heat to incoming combustion air with efficiencies as high as 80% of incoming flue temperatures. It can be used for air preheats up to 1400° F. □

What is believed to be the world's largest vegetable oil deodorizing system will be designed and erected by Blaw-Knox's Chemical Plants Division for Honeymead Products Co., Mankato, Minn. Capable of producing ten tank cars of 600,000 lbs. of deodorized soybean oil per day, the huge plant will be completely continuous and automatically controlled. □

The Badger Manufacturing Co. of Cambridge, Mass., has been selected as one of the companies which will design, procure and construct National Research Corp's. zirconium processing plant in Pensacola, Fla. Tentative completion date for the plant has been set at mid-1957.



Forty long tons of high-grade sulphur per day will be turned out in this close-to-half-a-million-dollar plant of the Montana Sulphur & Chemical Co., Billings, Mont. Designed and engineered by Badger Mfg., the plant will produce the sulphur from hydrogen sulphide gases which were formerly flared or used for fuel. In addition, a hydrogen sulphide recovery plant was built, engineered by Proctor Eng'g. Co., Tulsa.

Substantial expansion of Plaskon polyester and liquid phenolic resins is planned at the Toledo plant of Allied Chemical's Barrett Division. Plans call for more than doubling polyester resin capacity and nearly quadrupling phenolic resin capacity. The new facilities will come into operation by stages, with final completion set for mid 1957. ☐

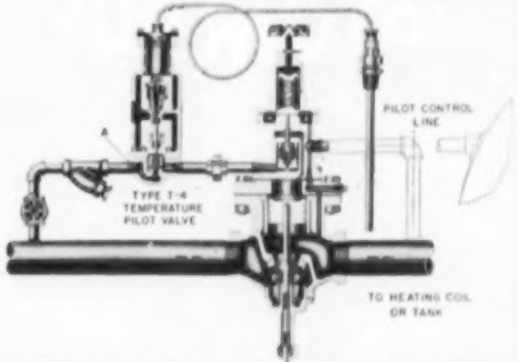
A multi-million-dollar contract to design, engineer and construct a 50,000 ton/year butadiene plant for the Odessa Butadiene Co. has been awarded to Fluor Corp. Construction is underway near Odessa, Tex., with completion expected in the summer of 1957. Facilities will include a dehydrogenation section using the Houdry process to convert butane into butadiene, and a purification unit employing the Esso C.A.A. process. ☐

The $5 million expansion program of Shea Chemical Corp., started last August, is now about 80% complete. Most important feature of the four-plant enlargement program is the addition of 140% to the firm's capacity for producing elemental phosphorus. This in turn will permit doubling the production of sodium phosphate and adding one-third to the phosphoric acid capacity. ☐

Thermal Research & Engineering Corp. has been granted exclusive rights to manufacture and sell high intensity combustion devices developed and patented by The Lummus Co. The equipment involved in the licensing agreement centers about a patented Lummus combustion device which provides high intensity, clean combustion with all grades of refinery gas and petroleum products. ☐

DON'T GET HOT *under the collar!*

... THERE'S A FOSTER TEMPERATURE REGULATOR TO CONTROL THE HEAT



ARE YOUR MAINTENANCE COSTS TOO HIGH DUE TO INACCURATE TEMPERATURE REGULATION?

MAYBE they are and you don't realize it. At any rate it will pay you to investigate the Foster line of temperature regulators for controlling temperatures of liquids and gases.

Foster manufactures a complete line of regulators for use in power or process plants, laundries and business buildings — for hot water storage heaters, fuel oil heaters, pasteurizers, ovens, driers, cookers and other heating and cooling equipment.

They are available in single or double-seated construction; direct or reverse acting for cooling. The Foster combination Pressure and Temperature Regulator reduces piping costs and assures control of temperature at any pre-determined pressure.

The Foster Type T-10 Temperature and Pressure Reducing Regulator shown here, permits not only the adjustment of the temperature being regulated, but also the adjustment and automatic regulation of the maximum steam pressure to be applied to the vessel.

All regulators are manufactured of materials to insure extra long life and minimum maintenance in any specific field.

If you have a temperature control problem, consult your Red Book for address of nearest Foster Representative, or get in touch with us direct. Ask for your copy of **Bulletin T-101.**

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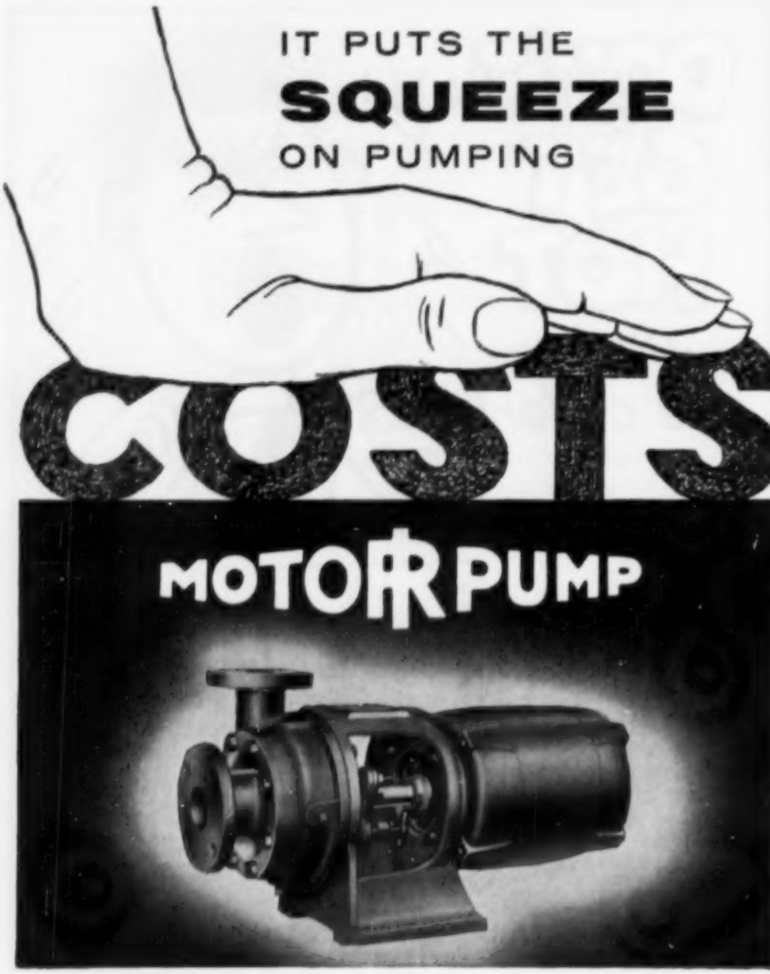
- FLOW TUBES



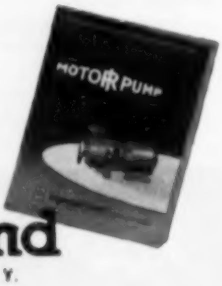
When you compare the Motorpump with any other pump . . . feature by feature . . . size by size . . . you'll quickly see why it is out in front for all liquid handling applications.

Installing it gives you *proof*. For one thing, you'll generally find you can use a *smaller* Motorpump to do the work assigned to pumps of larger horsepower. So costs are lower.

• Moreover, Motorpumps are so compact and efficiently designed that you save space and reduce power consumption. Installation is also simplified because they can be mounted in *any* position—on floor, wall or equipment—with no foundation needed!

Get to know the I-R Motorpump line—ranging in size from ¼ to 75 hp, 5 to 2800 gpm with heads to 650 feet.

Send for latest bulletin giving full data needed to choose a Motorpump.



Ingersoll-Rand

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NUCLEAR NEWS

AEC has given notice that it proposes to waive its statutory rights to inventions or discoveries resulting from the use of certain materials made generally available. These are: source materials, special nuclear materials, and heavy water; radioactive and stable isotopes, special materials, and materials resulting from irradiation services provided by the Commission at its installations; radioisotopes sold at 20% of the catalog price for biomedical and agricultural research. The notice does not affect any contractual arrangement to which the AEC is a party. □

To give an accurate accounting of what happens to such isotopes as radioactive cesium, ruthenium and antimony when dumped into the soil as waste, General Electric's engineers at Hanford have developed an "eye" which consists of a sodium iodide crystal in a watertight, windowless aluminum container. Suspended by a cable and lowered into narrow test wells, the eye detects gamma rays present in the surrounding soil and transmits this information to a strip chart recorder above ground. □

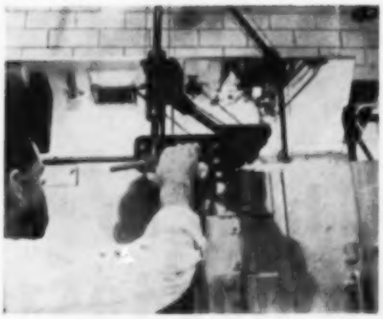
A new experimental graphite reactor in operation at the Hanford atomic plant is expected to speed up research into the more efficient production of fissionable materials. The new $200,000 test unit is "critical" and therefore develops more neutron flux than former sub-critical reactors at Hanford and gives more accurate results.

The unit is expected to be used for the evaluation of methods of constructing uranium fuel pieces and distributing them within present atomic reactors. It may also help suggest improved designs for any new reactors built in the U. S. □

A Nuclear Fuel Division to produce nuclear fuel elements and nuclear reactor cores has just been formed by Olin Mathieson Chemical Co. The company feels that power supplied by nuclear fuel will play a vital part in our future economy.

Temporarily, equipment is being installed in a reconstructed section of the company's Winchester Arms plant in New Haven, Conn. Pilot operations are already on-stream, a larger facility will come into operation within the next 18 months to permit full-scale production of nuclear elements.

While initial demand for nuclear fuel elements and nuclear reactor cores will come primarily from the military, the company feels that growing demand from industry can be expected as the use of nuclear power sources increases. □



Another milestone in the atomic age was passed when Oak Ridge National Laboratory recently completed its first ten years of the production and distribution of radioisotopes for use in medicine, industry and agriculture. The laboratory, operated by Union Carbide Nuclear Co., has, through its radioisotope program, fostered a new phase of American industry. Estimates of the total savings to industry alone resulting from radioisotope applications have been placed at over $200 million annually. The radioisotope bottling unit shown in the picture is only one of the modern processing facilities that have replaced the crude equipment of ten years ago.

A million pounds of reactor-grade beryllium metal will be purchased by AEC from the Beryllium Corp., Reading, Pa., and the Brush Beryllium Co., Cleveland, O. Each company will supply half, deliveries will be made over a five-year period at an average cost of about $47 per pound. □

A new company, Kermac Nuclear Fuels Corp., has been formed to mine and mill uranium ore in the Ambrosia Lake area of New Mexico. The new company, owned by Kerr-McGee Oil Industries, Inc., Pacific Uranium Mines Co., and Anderson Development Corp., will mine and mill the mineable ore reserves held by the three companies within 25 miles of the presently proven ore bodies. Kerr-McGee will hold the majority interest, will staff and operate the new company. Ambrosia Lake area is considered to have a potential uranium ore reserve among the largest in the United States, and the three parent companies feel that Kermac has a good chance to become one of the largest uranium mining and milling companies in the country. □

A new Department of Radiation Research has been established at Mellon Institute, Pittsburgh, Pa., to begin the famous research organization's first major research effort in the field of peaceful atomic energy applications. Initial radiation source for the new project will be a 3-million-volt Van de Graaff accelerator now on order from High Voltage Engineering Corp. Heading the new department will be R. H. Schuler, formerly of Brookhaven National Laboratory. □

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A Pittsburgh Meeting Report

Industry Recruiting in Colleges . . . how to how not to

Hard facts, not glowing picture of soft life, said to be approach most likely to recruit 1957 graduates for jobs.

One day last Spring, a big four-engined plane wheeled to a stop on an air-strip near a large southern university. A few minutes later it took off with an unusual cargo—40 of the school's most promising senior engineers. No ultramodern plant inspection trip—instead, this was the latest in large-scale, ultra-efficient recruiting undertaken by a firm which found it desirable to keep the students away from their classes and on the far west coast for an entire week.

Maturing Experience or Skylark?

While a trip to the west coast, with tours of plants and the liberal sampling of country club cuisine can no doubt be broadening to even the most staunchly established fraternity man, there are apparently some harried faculty members who believe such tutoring could better be done after the school year is over.

While companies may feel that industry's present great need for engineers justifies a recruiting venture such as this week-long tour, the professors tend to oppose such methods being used at a time when the student is in a critical phase of his technical training.

Recruiting—How and When?

Just how industry should go about the admittedly vital task of recruiting engineering graduates for its needs, and when it can best carry on this operation, was given a penetrating going-over last month at A.I.Ch.E.'s National Meeting in Pittsburgh. A panel made up half of educators and half of industry men * considered problems involved, cited the pros and cons, the good points of present practice and the bad, and ended their session with concrete recommendations.

Conclusion: Recruiting is now a major operation in a large number of companies, is, in many cases, not being handled as well as it should be, complaints have come from both industry and the colleges.

Panel moderator Webb, in considering the scope of recruiting today, cited a recent National Industrial Conference Board survey of 100 companies. Of the companies surveyed, 52% had standardized college recruitment programs, and of the companies with 5,000 employees or over, 88% had standard programs. Perhaps the most significant figure is that 52% of the companies with programs have instituted them since 1945. In dollars and cents the 1954 campaign for college students cost companies anywhere from \$50 to \$4,000 per student recruited, with the average running between \$300 and \$500 per recruit. And even then only 24% of the companies surveyed obtained all the recruits they wanted in 1954. Seven months are spent in recruitment by 24% of the companies, and the entire year by 11%. With so much concerted effort and strong recruiting it might be expected that the young graduate engineers are spoiled and tend to job-hop for the many advantages offered, but only 4% of the companies said they had excessive turnover in the college recruited group. Most said that the group is among the most stable they have.

How to Recruit—A Threefold Problem

Industry must have engineers. The graduating senior must find a position. The colleges and universities must see that their students are placed in the position best suited to their talents—but they must also see that faculties remain filled and graduate schools get the students they should get even if this means industry must wait for the services of outstanding individuals.

In these three needs there is conflict. Particularly today, when the demand for engineers exceeds the supply (in one school, the panel brought out, there were 400 jobs offered to 200 graduating engineers) and the methods used by industry to recruit have often been labeled high-handed, high-pressure, and even unethical.

If a good job of recruiting graduating engineers for industry is to be done, we must know just what industry looks for in a student, what the student expects in an interview, and what the college wants when the industrial recruiter comes on campus.

What Industry Looks For

Industry needs men as one of its basic "raw materials." When the recruiter goes to the college campus he looks at three basic facts in each student: (1) depth and scope of technical knowledge, (2) personality, and (3) ability to learn. In evaluating the students during each interview the recruiter tries to assess the student's:

(1) Experience
(2) Education and training
(3) Early home background
(4) Present social status
(5) Health
(6) Manner and appearance
(7) Motivation and personality.

What the Student and College Look For

The student is at the first major step of his industrial career when he faces the industry representative. He wants to know: (1) just what type of company does the recruiter represent, (2) what is the reputation, in production, in research, of the company and the men in it, (3) what is the size of the company, and perhaps most important of all, (4) what is the exact kind of job the student will get in the company, what are its specific demands and duties, who will the student be working with and in what way (students have a strong tendency to look for a challenge in their first job).

A major factor to the student that should not be overlooked by the recruiter is the student's own location, the place his wife, family or sweetheart lives.

Salary is always an important factor,

(*Continued on page 90*)

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* *Moderator:* G. A. Webb.

For Industry: Fred Denig, Koppers Co.; J. W. Reynolds, Chem. & Met. Div. of General Electric; and C. B. Hill, Jr., Organic Chem. Dept., Du Pont.

For the Colleges: E. W. Schoenborn, North Carolina State; J. E. Hedrick, Cornell; and T. R. Ryan, Carnegie Tech.

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Our long and broad experience in researching, designing and building dryers for highly diverse industries (rubber, tobacco, foods, explosives, textiles, are a few), gives us a backlog of practical, production-proven knowledge to help *you* to more efficient, economical, guaranteed-quality product drying.

WHEREVER THERE'S A DRYING PROCESS
A Sargent Dryer will do the job better, at less cost

Want detailed information? Just call your nearest representative or write us direct.

*There are a few! A good cigar or a pack of cigarettes to anyone writing us the name of such a product.

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Graniteville, SINCE 1852 Massachusetts

PHILADELPHIA 19 — F. E. Wasson, 519 Murdock Road
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CHARLOTTE, N.C. — W. S. Anderson, Carolina Specialty Co.
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Dryers for the process industries . . . single or multiple conveyor; tray, pole or tunnel; stationary or rotary; high speed or low; heavy or light capacity; continuous or batch methods; for laboratory or production line.

S-A's exclusive hex-slot in the supporting bracket allows you to slide pre-adjusted rollers in or out quickly and easily without the use of tools.

No. 745 Standard Belt Conveyor Idler

S-A CARRIERS ARE BEST...

Here's why . . . The following S-A Idler features provide longer, maintenance-free idler life and dependable, trouble-free operation:

No. 744—45° troughing Idler

SPUN END, ONE-PIECE ROLLERS . . . consisting of carrying surface and ends spun from a single piece of heavy gauge steel tubing plus an inner bearing tube welded to spun ends. Standard carrier, 4" diam., 5" diam. also available.

PERMANENTLY SEALED . . . precision ball bearings are protected by a die-cast double labyrinth seal which will not corrode or wear, insuring protection of bearings from dirt and moisture.

PRE-LUBRICATED . . . sufficient grease is sealed into each roller to last the normal life of the carrier—Alemite fittings also provide for easy re-lubrication.

COMPLETE LINE . . . includes a type and size for all of your conveyor requirements.

IN STOCK FOR IMMEDIATE DELIVERY

For complete information
WRITE TODAY
for Bulletin 355.

NEED A BELT CONVEYOR?

Build it yourself and SAVE with the "SACO" Sectional Belt Conveyor!

Designed to meet the needs for an economical solution to conventional bulk conveying equipment. Includes all necessary component parts for quick, easy assembly in your plant.

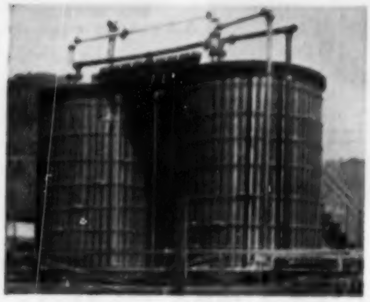
WRITE TODAY FOR BULLETIN 1454

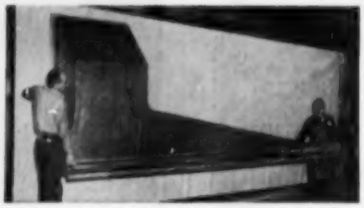
STANDARD PRODUCTS DIVISION
STEPHENS-ADAMSON
MFG. CO.
57 Ridgeway Ave. Aurora, Illinois

HAVEG® *News*

Wherever CORROSION RESISTANCE is a Factor

HAVEG PLASTIC TANKS MEET EVERY SERVICE REQUIREMENT





HAVEG FUME SYSTEMS, CORROSION RESISTANT PROCESS EQUIPMENT

HAVEG STORAGE TANKS, REACTORS, COLUMNS, TOWERS, PLATING TANKS, FILTERS and similar equipment are now manufactured in every type and size, rectangular and cylindrical—in a wide range of Haveg grades, combined with selected chemically inert materials to provide exceptional resistance to corrosive acids, hypochlorites, salts, alkalies and various oxidizing agents.

HAVEG PLASTIC TANKS are tough and durable. Large Haveg storage tank installations have been in continuous service at leading processing plants as long as twenty-five years—under the most extreme corrosive conditions.

HAVEG TANKS are economical to install . . . easy to maintain. **NEW POLYESTER GLASS** constructions, for example, *cost considerably less installed than lead or rubber-lined, stainless or even mild steel types in many instances* . . . offer bonus savings in reduced steel for support because of their extreme light weight! Haveg plastic tanks require no painting or costly maintenance . . . can be readily field repaired where necessary.

Whether yours is a new or replacement installation, investigate the advantages of Haveg corrosion resistant plastic tanks and process equipment for your process operations. Write for Bulletin C-13.

Haveg fume duct, hoods, stacks, fans and fittings in the Haveg reinforced plastic best suited to handle the corrosive fumes and gases at your plant, offer the most practical and economical system possible wherever fume removal is an operational requirement.

Engineered for use up to 350°F., Haveg fume removal units are light in weight for easy, low cost installation, or for heavy duty service where required. Hoods are readily molded and joined in varying shapes and sizes . . . stacks up to 12 foot diameter and over 200′ high can be flanged for quick assembly—or resin-welded as a single unit! Complete fittings are available from stock, or can be custom-fabricated to your specific requirements. A Haveg engineer will be glad to assist you in planning a complete system for your plant . . . or selecting Haveg units to replace deteriorated apparatus in your present system.

You can make anything in Haveg that you can make from metal. Haveg is tough, durable, machineable, easily and quickly altered or repaired in the field.

Haveg Bulletins F-7 and C-13 give detailed data on the complete line of corrosion resistant Haveg process equipment and resin cements to solve *every* corrosion problem. Write for your copies at no obligation.

HAVEG PLASTICS OF TOMORROW SOLVE YOUR CORROSION PROBLEMS TODAY

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Atlanta Exchange 3871 · Chicago (Wheaton) WHeaton 8-3225 · Cleveland WAshington 1-8760 · Detroit (Livonia) KEnwood 1-1785 · Houston JAckson 2-6840 · Los Angeles MIchigan 1105 · New York (Westfield, N.J.) WEstfield 2-7383 · Seattle Main 8006 · Denver HIlmont 7-0433

INDUSTRY RECRUITING

(*Continued from page 88*)

but it is not, in the experience of recruiters, students, and faculty, the prime factor.

In the interview itself the student wants to be at ease in a friendly atmosphere without high-pressure sales talk or a smug and superior attitude on the part of the interviewer. He wants the interview to be direct and informal, but he wants it to be more than mere routine and does not want the interviewer to monopolize the interview. The student wants to be able to express himself and show his worth. He wants conversation, not interrogation, and he expects the interviewer to understand the student's position and have a wide knowledge of his own company. And the student asks that the company always send a follow-up letter whether he gets the job or not.

The Recruiting Program

Considering the needs and interests of industry, the student, and the college, the discussions of the panel evolved into a basic pattern for an efficient recruiting program today:

(1) Schedule the visit. Make it a custom as far as possible for the recruiter or team to visit the campus at the same time each year. If possible it is good for the recruiter to visit the campus and the faculty at other times during the year. Continuous relations can be important. Some recruiters come and go too fast. Make the visit long enough to do the job without a sense of haste.

(2) Recruiters should be thoroughly familiar with the college, its courses, and its faculty. They should know more members of the faculty than just the department heads. Close association between faculty and industry is one of the best ways to know what a college has to offer, and what the company has to offer the student. Very often a student's mind is made up before the recruiter arrives, and it is continuous relations that will do the best job in the long run. Generally, professors feel it is a mistake to recommend a specific company to their students, but they can be a great aid to the recruiter if they are thoroughly familiar with his company.

(3) Give a definite idea of what is wanted, what the company is offering the student. The information given should enable the student to project himself into the company as an employee. Give him the facts! Too many companies fail to do this. Let the college know what is said and offered to the student: the college has a vital in-

terest in the student's welfare. Don't forget, the recruiter is interested in the college's product. It is highly important that the recruiter know all about his company, and understand the needs of the student, because today companies are basically similar in what they have to offer a beginning engineer and it is very often some small point that decides a student.

(4) Make no excessive glittering offers. The one-week all-expenses paid trip to the west coast on that four-engined aircraft is not a good way to recruit students. Offer them a good job and tell them what it is and forget the wide sandy beaches, tennis courts, and unlimited expense accounts. Many colleges are up in arms over what they consider unethical methods, such as the padded expense trips, unwarranted bonuses, and even putting the student on the payroll long before he finishes school. (In this regard, companies should not, and usually do not, look upon their aid-to-education programs as recruiting tools, except in the long-range building of good-will by showing an interest in education.)

(5) The question of how to organize the recruiting effort is open to debate. Some companies insist that a good recruiting program is a full time job, with a full time staff that does nothing else. Other companies consider that a part-time man who is himself mainly engaged in the production work of the company makes a better recruiter. Both systems seem to have certain advantages. But whatever system is used, it is generally agreed that the man who interviews a prospective engineer should be technically trained, if possible he should have done work similar to that the student will be doing, and he should have a wide knowledge of his company.

(6) Look at the long-range and not just the immediate needs. Study a student for his potential, and if he has real research or other specialized talent that must be developed in graduate work, don't steal him for short range needs. In the long run this will help industry, the student and the college. For the colleges, the loss of top seniors to industry is harming the overall quality of faculty and graduate members, and, eventually, the quality of the subsequent graduates themselves.

The College Problem

There is no doubt that today the colleges have a problem in keeping the engineering faculty they must have. The number of teachers involved is not large, but it is a vital segment. It is men with industrial experience who are needed, the good students who went into industry and who are needed to teach.

(*Continued on page 92*)

CONSECO SAVES CLIENT $25,000!

THE JOB: TUBE SHEET REPAIRS IN HIGH PRESSURE HEATER

The 3½" thick tube sheet was leaking badly. Our job was to remove old weld by drilling and burning, uncover and pierce 44 tube ends below tube sheet, apply 44 tapered steel plugs and replace weld. A previous successful repair attempt (not by CONSECO) had cost the client $18,000.

In 8½ working days, at a cost of only $4,000 three CONSECO men completed the work. Hydrostatic tests, using fluorescent dyes and black lights, plus circulating tests of 2500 lbs. of hot water pressure, proved everything satisfactory.

And our client saved the cost and delay of retubing, estimated at $25,000. *This shows what can be done by CONSECO SERVICE on any tubular equipment. Available anywhere . . . 24 hours a day, 7 days a week, Sundays, all holidays. 'Phone Maintenance Department.*

Send for Bulletins giving complete engineering data on these products.

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Designers and Builders of Equipment for Power, Refining, Chemical and Marine Industries

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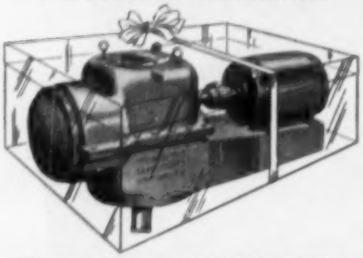

Gear reducers, motors, motor supports, couplings, shafts, impellers, and base mountings . . . all pre-assembled for quick, easy installation and operation on your tanks.

Philadelphia Mixers offer you more value per dollar

Solve any fluid mixing problem with Philadelphia "packaged" Mixers . . . by standardizing on simple, easily maintained Philadelphia Mixers, you get these advantages:

COMPLETELY INTEGRATED "PACKAGED" SERVICE. Philadelphia designs, and manufactures in one plant, every major component, except motors and bearings . . . Through this controlled, responsible source, you obtain complete solution to your mixing problems.

QUICK-CHANGE GEAR DRIVES. Easily accessible, helical change-gear set allows ready selection up to 14 different standard speeds to meet changing needs. Spiral bevel gears lapped, assembled in matched pairs and micrometer tested for long, quiet operation. All drives A.G.M.A. rated.

FULL RANGE OF SIZES. Choose the Philadelphia Mixer suited to your needs. Six basic models, 1 to 100 HP. Keep in mind Philadelphia can build to sizes and specifications larger than usually available.

UNITARY MECHANICAL SHAFT SEAL. Positive leak-proof shaft seal for closed tank agitation gives long maintenance-free service life. When necessary, it can be installed and replaced in minutes. No special lifting equipment needed.

HEAVY DUTY SHAFTS & BEARINGS. Extra large output shafting results in less shaft deflection at stuffing box or mechanical seal, steady operation of overhung mixer shafts. Bearings oversize, with generous service factor.

Doesn't it stand to reason that these advantages add up to a bigger, better-designed, more powerful unit for your money? Be convinced, just write for Bulletin A-156.

philadelphia mixers

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FLUID AGITATORS • FLEXIBLE COUPLINGS

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INSTITUTIONAL NEWS

Convinced that a lack of science curricula at the high school level is one of the prime causes of today's critical shortage of engineers, Selas Corp. of America is doing something about it. The company is presenting to the Upper Dublin Township High School, Fort Washington, Pa., a complete, up-to-date engineering reference library. In addition, the company encourages and arranges for groups of high school students and teachers to visit its plant.

The Fifth Annual Instrumentation Conference will be held at the School of Engineering, Louisiana Polytech, Ruston, La., November 1-2, 1956. Program will be detailed and varied, will be a practical program which will tell how to install existing instrumentation. Included are these six papers: Radioactive Density and Level Measurements, P. E. Ohmart; Organization of Instrument Departments for Processing Plants, G. C. Carroll; Graphic Panels and Data Reduction Instruments—Present and Future, M. D. Shriver; New Methods in Gas Measurement, The Foxboro Co.; Automatic Operation in Oil and Gas Production, R. N. Crossman, Jr.; and Automatic Controls on a Continuous Digester, P. Law.

Exhibits of new equipment in instrumentation and process control will be displayed by representatives of leading manufacturers of such equipment. □

The Chemical Market Research Association will hold a meeting at the Harvard Business School in Cambridge, Mass., November 13 and 14. The theme of the meeting is New Tools for Market Research. Headquarters for the meeting will be the Sheraton Plaza Hotel in Boston. □

The Commercial Chemical Development Association will hold its November meeting on November 1 this year at the Terrace Plaza Hotel, Cincinnati, O. Subject: Detergents. □

AEC has accepted the enrollment of 63 scientists and engineers, 50 of them from 24 foreign nations, for graduate studies in the Commission's International School of Nuclear Science and Engineering. The school, operated for the Commission by the Argonne National Laboratory near Chicago in cooperation with North Carolina State College and Penn State University, is providing intensive unclassified studies in reactor technology and related subjects pending the establishment of adequate training facilities in regular educational institutions here and abroad. □

The semi-annual meeting of the Air Pollution Control Association will be held at the Rice Hotel, Houston, Texas, December 3, 4 and 5. The morning session will feature a discussion of the Houston air pollution situation and legal aspects in the Houston area. Other, more general sessions will include: symposia on the odor problem, the sulphur problem, and the dust problem; a general subjects session. Plant trips have been arranged. □

The annual meeting of the Society of Rheology will be held in Pittsburgh, Pa., on November 7-9 at the Webster Hall hotel. Among the papers scheduled are ones on such topics as adhesion, the effect of hydrogen on metals and metal alloys, methods for the experimental determination and theoretical evaluation of viscosity data, and the mechanical rupture of polymeric materials. □

INDUSTRY RECRUITING

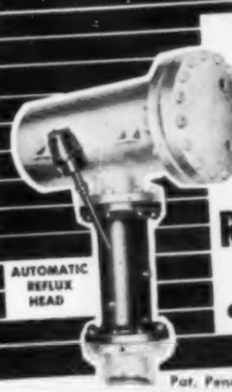
(Continued from page 91)

The crux is that the colleges need not just any man, but the right kind of man who has a well-rounded industrial experience rather than a specialized one. Industry must somehow find a way to "plow back" into the colleges the men needed to turn out the engineers we need in the future.

Conclusion

The size and importance of college recruiting programs for young engineers is large and growing. Much is being done that is neither healthy nor truly efficient in the long run. Both the colleges and industry are vitally concerned with the problem which is an essential operation for both of them. And the necessity for careful study of scope, goals and methods is clearly needed when we consider that one of the largest and most vigorous chemical companies, one that has a full-time, fully-staffed program, succeeds in recruiting only some 8-10 of every 100 students interviewed.

DISTILLATION REFLUX HEADS and REDISTRIBUTORS
—for improved column performance



Pat. Pending

AUTOMATIC REFLUX HEAD
Explosion-proof, electrically-operated for high vacuum, pressure and temperature, and for corrosive and hazardous service. Eliminate reflux control problems with its simple, accurate and dependable operation.

COLUMN DISTRIBUTOR
Pat. No. 2,639,130
Distributes liquid evenly over the packing and minimizes channeling. Improvements to 100% in plate efficiency are usually possible. Especially suitable for vacuum distillation. Readily installed in existing installations.

Reflux Heads and Redistributors are available in most metals and made in all sizes including large diameters. For further information write for Bulletin No. 55-1.

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GET INTO BOOMING PAPER BUSINESS

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AUTOMOBILE PANEL BOARD MACHINERY—75 TONS/24 HOURS. NEW 1955—ONLY USED 10 MONTHS. COST OVER 1½ MILLION—SELL AT ENORMOUS SACRIFICE. REMOVED FORD MOTOR CO., DEARBORN, MICHIGAN.

Preparation equipment
1—1955 Model Victory Beater—for treating fibrous material, refining and preparing—complete with 400 HP and controls—fully push-button automatic.

Forming Machine
1—1955 Model Machine for forming fibers with incorporated resins into continuous sheets, 126" wide slitting and trimming into panels—all automatic—complete with electronic controls—motors—pumps, etc.

Automation System
1—American Mfg. Automation System for automatically handling the above panel boards on 24 second cycle. Complete with suction equipment—motors—controls. This system feeds the panel boards to hydraulic presses below.

Hydraulic 15 Opening—Hot Plate Presses
Two—1200 Ton HPM Presses—size 100" x 120". Each press handles 15 sheets of panel board at one time—with automatic loaders and unloaders—each press has 8 cylinders—200 psi—with pumping units—200 HP motors, etc.—all complete.

Trimmers
2—Maier—126" slitters—for trimming panel boards to size.

Above equipment removed from Ford Motor Co., Dearborn, Michigan. Entire automobile panel board mill shut down. Space needed for new car models.

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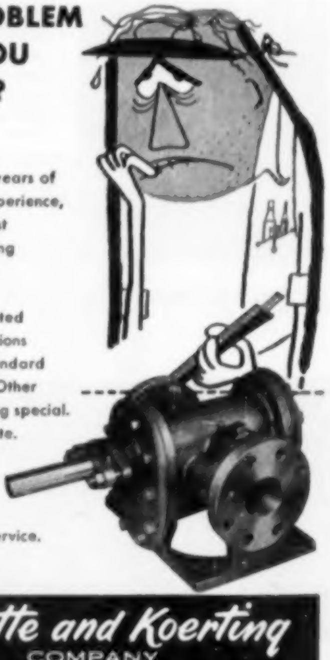

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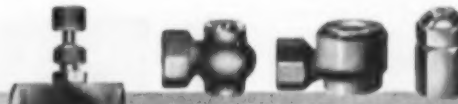
Jet Apparatus: Ask for Condensed Bulletin J-1. | Rotameters & Flow Indicators: Ask for Condensed Bulletin 18-AA | Valves: Ask for Condensed Bulletin V-1. | Heat Transfer Apparatus: Ask for Condensed Bulletin HT-1 | Gear Pumps: Ask for Bulletin 17-A.



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CEP CAMERA . . . PITTSBURGH ALBUM

EXPLOSION!

800 pounds of coal dust sets off conflagration shown at left, witnessed by chemical engineers, courtesy Bureau of Mines.

THE HONORABLE CLIFFORD C. FURNAS,

Assistant Secretary of Defense for Research & Development, shown at banquet (left), a study during an interview by the press (center).

PITTSBURGH ATTENDANCE
1,600
—Biggest yet for a National Meeting!

FRANKLIN LECTURER

Raymond P. Genereaux shown delivering luncheon address, one of highlights of Pittsburgh meeting.

TV—

Left, President Whitman being interviewed during half-hour KDKA telecast, while Secretary Furnas awaits turn. Above, lady chemical engineers awaiting cue while Professor Monrad interviews students.

FROM HERE AND THERE . . .

PERKIN MEDALIST

Edgar C. Britton, Dow Chemical, being congratulated at the Waldorf Astoria banquet by President Whitman.

GATLINBURG CONFERENCE

Deans of engineering schools heard an address by AEC Commissioner Libby (right), who is being congratulated by Professor Marshall, A.I.Ch.E. director (left).

AT "GET ACQUAINTED" PARTY

H. B. Coats, Blaw-Knox, general chairman; Mrs. Coats, co-chairman, Ladies Program; Mrs. Hoak; R. D. Hoak, Mellon Institute; Mrs. Wilson; P. J. Wilson, Jr., U. S. Steel.

C. C. Monrad, Carnegie Tech, Program chairman; Mrs. McAfee, co-chairman, Ladies Program; Jerry McAfee, Gulf Res. & Devel. Co., vice chairman; John Bowman, Mellon Institute.

J. G. Bradshaw, Koppers, secretary-treasurer; Mrs. Bradshaw; C. F. Hauck, Blaw-Knox, Public Relations chairman; Mrs. Hauck, Ladies Program; Tom Liggett, Hotel & Hospitality vice-chairman.

T. F. Reed, U. S. Steel; Mrs. Reed; R. S. Rhodes, Koppers, Entertainment chairman; Mrs. Ohlsol; E. O. Ohlsol, Pittsburgh Coke & Chemical, Plant Trips chairman.

J. H. Obey, Mellon Institute, Entertainment vice chairman; Mrs. Obey, Ladies Program; J. S. Joseph, Koppers, Hotel & Hospitality chairman; Mrs. Joseph, Ladies Program; M. W. Ramer, Blaw-Knox, Public Relations vice chairman; Mrs. Ramer.

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MERCHEN SCALE FEEDERS

"give us accurate, continuous blending over a wide feed range"

Central Soya Co., Inc., blends millions of bags of animal and poultry feed a year at their new Chattanooga plant. Up to 50 different formula feeds are produced to exacting standards. Central Soya chose W&T Merchen Feeders because they give 1% minute-to-minute accuracy over a wide feed range. As seen in the picture, the feeders are compact — with no bulky enclosures.

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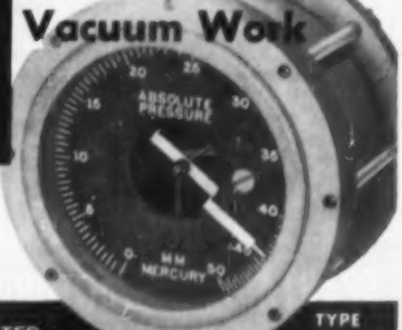
ABSOLUTE PRESSURE INDICATOR

For Precise Vacuum Work



Ranges: From 0–50 mm to 0–800 mm Hg. absolute in six ranges
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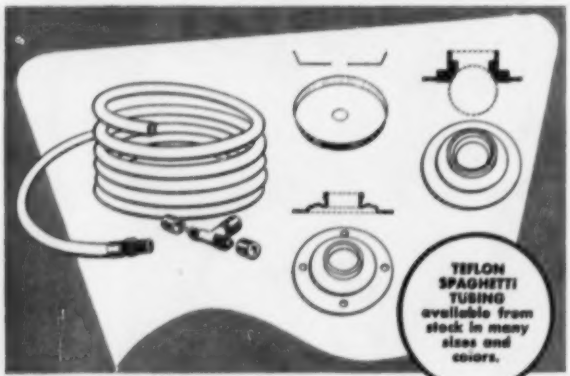

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CANDIDATES FOR MEMBERSHIP IN A. I. Ch. E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions.

These names are listed in accordance with Article III, Section 8, of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before November 15, 1956, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Ameen, Jamell, *Hopewell, Va.*
Bartkus, Edward P., *Wilmington, Del.*
Beutel, A. P., *Freeport, Tex.*
Bocquet, Philip E., *Ponca City, Okla.*
Bowen, E. Clinton, *Cambridge, Mass.*
Buell, Charles W., *Akron, Ohio*
Day, Frank, Jr., *Corning, N. Y.*
DeBauche, Leon A., *Toledo, Ohio*
Dintiman, L. L., *Texas City, Tex.*
Dorsey, W. S., *Brea, Calif.*
Duda, Richard F., *Paramus, N. J.*
Engel, Harold N., *Kansas City, Mo.*
Ford, James A., *Shreveport, La.*
Gilbertson, Dennis L., *Caracus, Venezuela*
Goodgame, Thomas H., *Houston, Tex.*
Hart, Robert C., *Kingsport, Tenn.*
Horner, John F., *La Marque, Tex.*
Hulette, Virgil H., *Springfield, Mass.*
Hyer, Joe, *Houston, Tex.*
Israel, Robert D., *Baton Rouge, La.*
Jacobsen, Fred M., Jr., *Texas City, Tex.*
Johnson, Robert Curtis, *St. Louis, Mo.*
Jones, Robert W., *Springfield, Mass.*
Kaiser, Edward W., *Western Springs, Ill.*
Karakas, Harry J., *Orange, Mass.*
Kixmiller, Richard W., *New York, N. Y.*
Kobs, Alfred W., *Houston, Tex.*
Langwill, J. P., *Huguenot, C.P., South Africa*
Lieffers, William C., *Garden Grove, Calif.*
Marion, Charles P., *Whittier, Calif.*
McLean, William W., *La Marque, Tex.*
McMahon, Edward J., *Pearl River, N. Y.*
McMahon, E. K., *Nashville, Tenn.*
Merritt, Gilbert S., *Long Beach, N. Y.*
Petty, Robert E., *Pittsburgh, Pa.*
Purcell, Robert H., *Richland, Wash.*
Reed, Leland M., *Allentown, Pa.*
Reed, Robert H., *Solvay, N. Y.*
Rubin, Frank L., *Wynnewood, Pa.*
Satterwhite, T. L., *Baytown, Tex.*
Todd, James A., *Grand Island, N. Y.*
Wales, Charles A., Jr., *La Marque, Tex.*
Wheeler, William N., *Perry, Ohio*
Wimmer, Llewellyn C., *Brooklyn, N. Y.*

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Allen, Richard K., Jr., *Havertown, Pa.*
Allen, W. W., *Jacksonville, Fla.*
Aubrey, Darryl C., *Mobile, Ala.*
Barry, Henry F., *Hammond, Ind.*
Bell, James P., *Havertown, Pa.*
Boeker, Bruce E., *Claymont, Del.*
Bolez, Carl A., *Allentown, Pa.*
Boliek, Paul E., *St. Albans, W. Va.*
Brand, Stanley H. F., *La Marque, Tex.*
Brommer, W. D., *Huntingdon Valley, Pa.*
Brunson, S. M., *Freeport, Tex.*
Burke, Joseph A., Jr., *Philadelphia, Pa.*
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Cannon, James P., *New York, N. Y.*
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Di Napoli, Robert N., *Lockport, N. Y.*
Donchez, Francis R., *Bethlehem, Pa.*
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Dougherty, Elmer L., Jr., *Freeport, Tex.*
Driscoll, R. E., *Houston, Tex.*
Edwards, Jack J., *Detroit, Mich.*
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Esposito, John M., *Scranton, Pa.*
Favelevic, Roberto, *Buenos Aires, Argentina*
Fazekas, Zoltan W., *Linden, N. J.*
Fetterman, David L., *Edgewood, Md.*
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George, Henry H., Jr., *Buffalo, N. Y.*
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Geyer, Gerald R., *Midland, Mich.*
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Gross, James A., *New Brunswick, N. J.*
Hansen, O. V., *Detroit, Mich.*
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Harris, L. Donald, *Huntington, N. Y.*
Harstad, A. E., *Tacoma, Wash.*

Hartig, Robert, *Dearborn, Mich.*
Hartman, Harlan, *Hot Springs, S. D.*
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Hunter, Thomas F., *North Madison, Ohio*
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Johnston, Bartlett, *Baytown, Tex.*
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Kongable, J. W., *Texas City, Tex.*
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Liller, William P., Jr., *Paden City, W. Va.*
Lindahl, Harold A., *Elmhurst, Ill.*
Litzinger, Gerald E., *Ashland, Ky.*
Lokay, Fred, *Pittsburgh, Pa.*
Masias, Alvaro, *Lima, Peru*
Mathews, Lloyd B., *Whiting, Ind.*
McGrath, Rodney L., *West Reading, Pa.*
Milenius, David L., *Akron, Ohio*
Miskinis, Richard T., *Woodbury, N. J.*
Montague, Joseph L., *Dayton, Ohio*
Neville, Joseph P., *Winthrop, Mass.*
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Payne, Howell B., Jr., *Houston, Tex.*
Pearson, Whitney L., *Libertyville, Ill.*
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Primus, Harold C., *Waukegan, Ill.*
Rathbone, Allan M., *Fort Worth, Tex.*
Ribbans, Robert C., III, *Bloomfield, N. J.*
Richardson, John L., *Whittier, Calif.*
Roberts, Robert Earl, *Cleveland, Ohio*
Savoie, R. C., Jr., *Baytown, Tex.*
Scherck, Edwin Leslie, *Staten Island, N. Y.*
Snider, John A., *Belle, W. Va.*
Sprague, C. B., *Conroe, Tex.*
Stark, Louis R., *St. Louis, Mo.*
Stout, George S., *Riverside, Pa.*
Swanson, Ronald Walter, *Vineland, N. J.*
Todorski, Z., *Arvida, Quebec, Can.*
Townsend, Francis M., *Norman, Okla.*
Tuli, Krishan Prakash, *Montreal East, Quebec, Can.*
Vail, Peter S., *Chicago, Ill.*
Van Huff, Norman E., *East Detroit, Mich.*
Van Wert, George H., *Peckville, Pa.*
Vath, James E., *Cincinnati, Ohio*
Warner, Robert E., *Allentown, Pa.*
Wengrzyn, Frank, *Ashland, Ky.*
West, John M., *Metuchen, N. J.*
Wheele, Roland L., *Akron, Ohio*
White, Kingdon W., *Framingham, Mass.*
Whitney, Clifford H., *Delmar, N. Y.*
Wright, Palmer W., *Midland, Mich.*
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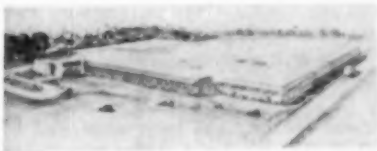
Affiliate

Flounders, John M., *Montreal, Quebec, Can.*
Litman, John A., *Uniontown, Pa.*
Paxton, Wilbur B., *Painesville, Ohio*



New plant of Automatic Switch Co., to be located at Florham Park, N. J., will double the company's capacity for production of solenoid valves and electromagnetic control. The company's entire operation is expected to move to the new plant by the end of this year.

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TYPE "F" SINGLE STRAINER—For use where the flow does not contain large quantities of foreign matter, and where the strainer can be temporarily out of service for cleaning. Available in sizes from 2" to 24". Baskets available with 1/32" to 3/8" mesh. Has a single perforated basket, convenient to handle and quickly accessible.

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RESEARCH NEWS

New experimental unit for the production of synthesis gas by partial oxidation of coal is now in operation at Olin Mathieson Chemical Corp.'s Morgantown, W. Va., plant. Although only an experimental unit, the new installation is capable of producing enough synthesis gas to make some 80 tons of ammonia or equivalent methanol per day. According to the company, it is expected that the partial oxidation process will eventually replace the present process at Morgantown, and will strengthen the plant's competitive position relative to newer plants using natural gas or petroleum as raw material. □

A new $500,000 addition to the chemical research laboratories of Ethyl Corp. has gone into operation at the company's Baton Rouge research and engineering center. The new building will be devoted to research in petrochemicals, chlorination, organometallics, electrochemistry and other fields, marks the second major expansion of Ethyl's research facilities at Baton Rouge within recent years. □

A new multi-million-dollar research center will be built by Koppers Co. on a recently approved-for-purchase 176-acre tract of land near Monroeville, Pa. Koppers expects that the scope of its research program will be tripled within the next ten years. □

A new light-stabilizing process for vinyl that provides about three times the outdoor durability previously obtainable has been developed by Monsanto's Organic Chemicals Division. In actual tests, not yet complete, the system has withstood 5,600 hours of accelerated artificial weathering before failure. □

The nation's largest privately financed jet fuels laboratory has been opened by the Texas Co. at its principal research center at Beacon, N. Y. The new quarter-million-dollar installation will enable Texaco to continue to expand its research in the growing field of jet fuels. The laboratory's "full-scale" combustors permit the highly accurate reproduction of actual operating conditions. □

Zone leveling has been employed by Bell Telephone Laboratories engineers to produce single crystals of exceptional perfection and uniformity. Most of the work has been done with germanium, but the principles involved have broad application. □

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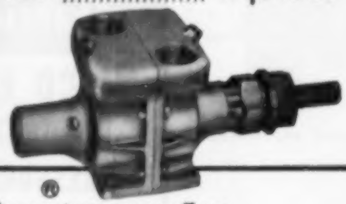

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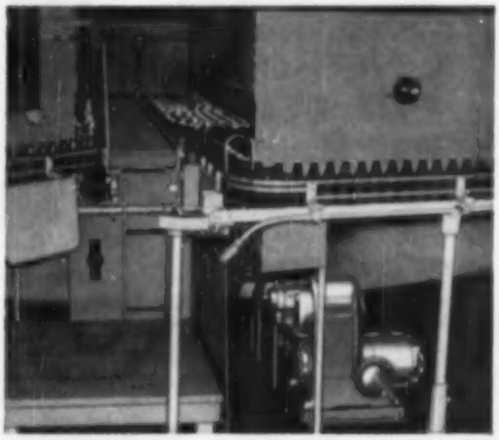

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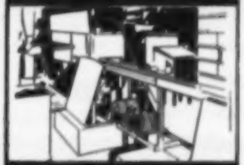
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FUTURE MEETINGS and Symposia of the Institute

MEETINGS **SYMPOSIA**

■ **ANNUAL—BOSTON, MASS**

Dec. 9-12, 1956. Hotel Statler.

See complete program on pages 52-53 et seq.

In Boston: Paul Revere, Old North Church.

■ **WHITE SULPHUR SPRINGS, W. VA.**

March 3-6, 1957. Greenbrier Hotel.

TECHNICAL PROGRAM CHAIRMAN: S. G Friedman, E. I. duPont de Nemours & Co., Benger Lab., Waynesboro, Va.

Computers in Chemical Company Control

CHAIRMAN: W. M. Carlson, du Pont, Engineering Service Div., Newark, Delaware.

The use of large-scale computers in handling payrolls, billing and ordering, sales forecasting, production control, etc.

Futures in the Chemical Industry

CHAIRMAN: R. E. Chaddock, Hercules Powder Co., Virginia Cellulose Dept., Wilmington 99, Del. Co-chairman: Geo. Rieger, Diamond Alkali Co., Cleveland Ohio.

Scientists, Engineers & Management Decisions—A Problem in Teamwork

CHAIRMAN: G. D. Creelman, Creelman Associates, 10524 Wilbur Ave., Cleveland 6, Ohio.

The psychological factors which must be considered to assure effective functioning of Operations Research (scientific decision-making) teams.

■ **PHILADELPHIA, PA.**

March 10 through 16, 1957.

EJC Second Nuclear Engineering and Science Congress & Exposition.

■ **SEATTLE, WASH.**

June 9-12, 1957. Olympic Hotel.

Industry's Role in University Programs on Nuclear Engineering

CHAIRMAN: John Kaufmann, Div. of Reactor Development, U. S. Atomic Energy Commission, Wash., D. C.

Chemical Engineering Data and Calculation Methods

CHAIRMAN: W. C. Edmister, Calif. Research Corp., Richmond Laboratory, Richmond, Cal.

Filtration

CHAIRMAN: To be named.

■ **BALTIMORE, MD.**

September 15-18, 1957. Lord Baltimore Hotel.

Drying

CHAIRMAN: Ralph E. Peck, Chem. Engineering Dept., Ill. Inst. of Tech., Chicago 16, Ill.

(Continued on next page)

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■ **ANNUAL—CHICAGO, ILL.**

December 8-11, 1957. Conrad Hilton Hotel.

TECHNICAL PROGRAM CHAIRMAN: Henry F. Nolting, Standard Oil Co., 2400 New York Ave., Whiting, Ind.

Fluidization of Solids

CHAIRMAN: E. R. Gilliland, Chem. Eng. Dept., M.I.T., 77 Massachusetts Ave., Cambridge 39, Mass.
Flow characteristics, rate of entrainment and heat transfer; fluidized reactors vs. fixed and moving bed reactors.

Effective Cost Control in Process Operations

CHAIRMAN: C. W. Nofsinger, The C. W. Nofsinger Co., 906 Grand Ave., Kansas City 6, Mo.

Evaluation of Projects from the Original Idea to the Investment Stage

CHAIRMAN: C. W. Nofsinger (see above).

Chemical Engineering Abroad

CHAIRMAN: Shelby Miller, Chem. Eng. Dept., Univ. of Kansas, Lawrence, Kansas.

Corrosion Resistant Alloy Materials of Construction

CHAIRMAN: G. Fred Ours, Carbide and Carbon, Charleston, W. Va.

Laboratory and Pilot Plant Techniques

CHAIRMAN: G. W. Blum, The Goodyear Tire & Rubber Co., 1485 E. Archwood Ave., Akron 16, Ohio.

■ **EVANSTON, ILL.**

April 8-9, 1957. Northwestern University.

Joint Instrument Symposium in cooperation with Instrument and Regulators Division of American Society of Mechanical Engineers.

■ **STATE COLLEGE, PA.**

August 11-14, 1957. Pennsylvania State University.

First National Conference on Heat Transfer, featuring Applied Heat Transfer. Sponsors: A.I.Ch.E., A.S.M.E., & College of Eng. & Arch., Penn State Univ.

UNSCHEDULED SYMPOSIA

Correspondence on proposed papers is invited.

Centrifugation

CHAIRMAN: James O. Maloney, Dept. of Chem. Eng., U. of Kansas, Lawrence, Kan.
The theory and quantitative aspects of centrifugation.

Direct Operating Labor Costs

CHAIRMAN: John Happel, Chem. Eng. Dept., New York U., University Heights 53, N. Y.

Size Reduction

CHAIRMAN: Edgar L. Piret, Chem. Eng. Dept., U. of Minnesota, Minneapolis 14, Minn.

Filtration & Centrifugation

CHAIRMAN: Horace Hinds, Jr., Corn Products Refining Co., Box 345, Argo, Ill.

Chemical Engineering Process Dynamics as They Affect Automatic Control

CHAIRMAN: David M. Boyd, 315 Ridge Ave., Clarendon Hills, Ill.

Ethylene Manufacture

CHAIRMAN: Hermann C. Schutt, 201 Devonshire St., Boston 10, Mass.

Dry Classification of Solids

CHAIRMAN: D. W. Oakley, Metal & Thermit Corp., Carteret, N. J.

(Continued on page 102)

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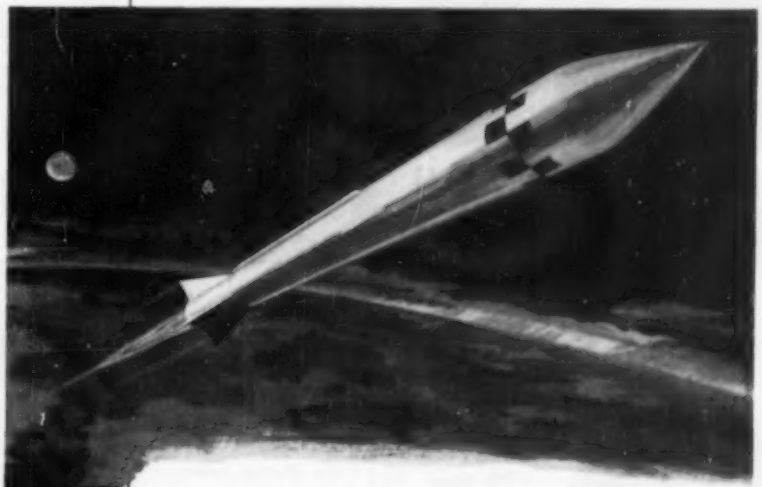

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FUTURE MEETINGS

(Continued from page 101)

MEETINGS — **SYMPOSIA**

New Chemical Engineering Construction Techniques

CHAIRMAN: S. A. Guerrieri, The Lummus Co., 385 Madison Ave., N. Y. 17.

Mineral Process Engineering and Mineral Economics

CHAIRMAN: L. A. Roe, International Minerals & Chemical Corp., 20 North Wacker Drive, Chicago 6, Ill.

Foams and Froths

CHAIRMAN: J. L. York, Ramo-Wooldridge Corp., 8820 Bellanca Ave., Los Angeles, Calif.

LOCAL SECTION MEETINGS

NEW YORK

Fall Education Series, Oct. 23-Nov. 27, 1956, "Digital Computers in Chemical Engineering."

Oct. 23: How Did Computers Develop; Concepts and Basic Components of Digital Computers.

Oct. 30: The Nature and Problems of Programming.

Nov. 7: Solution of a Chemical Engineering Problem from Conceptual Stage to Actual Run.

Nov. 13: The Digital Computer in Future Chemical Engineering Problems; New Developments and Their Contributions.

Nov. 20: Introducing and Integrating a Computer into an Engineering Organization.

Nov. 27: Demonstration Run of a Problem at IBM Computing Center; Review & Discussion.

For futher information and enrollment call: R. Morton, 30 Church St., New York 7, N. Y.

CHICAGO

November 7, 1956. Conrad Hilton Hotel.

1-day meeting. Morning: The Pros and Cons of Unionism for Engineers. Afternoon: What Management Expects of the Engineer.

Gen. Arrangements chairman: Hal M. Hart, Standard Oil Company, P. O. Box 431, Whiting, Indiana.

AUTHOR INFORMATION

Submitting Papers

Procedure to be followed is, in brief:

1—Obtain four copies of "Proposal to present a paper before the A.I.Ch.E.," plus one copy of "Guide to Authors" from Secretary, A.I.Ch.E., 25 West 45th St., New York 36, N. Y.

2—Send one copy of completed form to Technical Program Chairman for meeting selected from above list.

3—Send another copy to Mr. E. R. Smoley, The Lummus Co., 385 Madison Ave., New York 17, N. Y. (Asst. Program Comm. chairman).

4—Send third copy to Editor, Chemical Engineering Progress, 25 West 45th St., New York 36, N. Y. Paper will automatically be considered for possible publication in A.I.Ch.E. Journal.

5—If desired to present paper in a selected symposium, send fourth copy to chairman of the symposium.

6—Prepare five copies of manuscript. Send one copy each to Symposium chairman, Technical Program chairman, or both copies to former if no symposium is involved. Other three copies should be sent to Editor, C.E.P. Presentation at meeting offers no guarantee of acceptance for publication.

C. E. P.

Monograph

1. **Reaction Kinetics by Olaf A. Hougen** (74 pages; $2.25 to members $3.00 to nonmembers)
2. **Atomization and Spray Drying by W. R. Marshall, Jr.** (122 pages; $3.25 to members, $4.25 to nonmembers)

and Symposium Series

1. **Ultrasonics—two symposia** (87 pages; $2.00 to members, $2.75 to nonmembers)
2. **Phase-Equilibria — Pittsburgh and Houston** (138 pages; $3.75 to members, $4.75 to nonmembers)
3. **Phase-Equilibria—Minneapolis and Columbus** (122 pages; $3.75 to members, $4.75 to nonmembers)
4. **Reaction Kinetics and Transfer Processes** (125 pages; $3.75 to members, $4.75 to nonmembers)
5. **Heat Transfer—Atlantic City** (162 pages; $3.25 to members, $4.25 to nonmembers)
6. **Phase-Equilibria — Collected Research Papers for 1953** (113 pages; $3.25 to members, $4.25 to nonmembers)
7. **Applied Thermodynamics** (163 pages; $3.25 to members, $4.25 to nonmembers)
8. **Communications** (57 pages; $1.00 to members, $1.50 to nonmembers)
9. **Heat Transfer — Research Studies for 1954** (67 pages; $1.50 to members, $2.25 to nonmembers)
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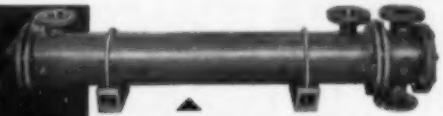

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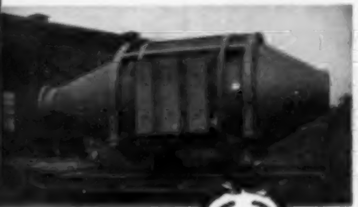

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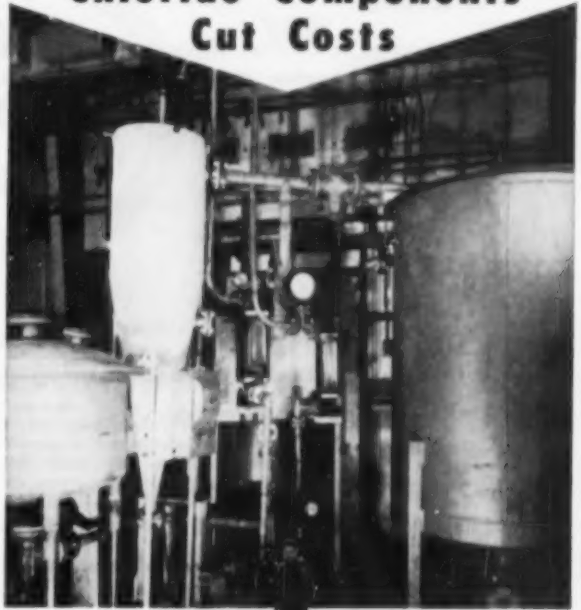

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News of the Field

FROM LOCAL SECTIONS

NEW LOCAL SECTIONS MOVE AHEAD

Through organizational trials, tribulations, and growing pains, eight new local sections now join A.I.Ch.E.'s most active sections.

In 1955 and 1956 eight new local sections joined the ranks of A.I.Ch.E.: **Alton-Wood River** (Nov. 1955); **Central Pennsylvania** (Sept. 1955); **Coastal Bend (Tex.)** (Jan. 1956); **Idaho** (March 1956); **Memphis** (Jan. 1956); **New Haven** (May 1955); **Syracuse** (May 1956) (See *CEP*, September 1956); and **Toledo** (Oct. 1955).

The achievement and the self-sacrificing work behind the simple existence of these local sections too often goes unknown and unappreciated. It means hard work for those chemical engineers who want to bring a local section to their area. Sometimes, as in the case of Coastal Bend, it means hard work for an existing section—the South Texas Section lent its support and many members to help form the Coastal Bend Section.

First, a club or society must be formed locally, officers must be elected and by-laws adopted, a program must be initiated and a meeting place selected, and then the engineers must be recruited as members. Only after the club has been operating for some time (the average is two years, with some sections, notably the Idaho Section, waiting as long as four years before they are ready to become a local section) does it apply and become a local section of A.I.Ch.E.

Membership

The growth records of the new sections have been impressive. **Coastal Bend** began with 22 members and now has 70. **Toledo** began with 28 and now has 78. **New Haven** formed with 45 members, now has 89, **Central Pennsylvania** has 35 and **Memphis** has 36. **Idaho,** starting with one of the lowest memberships, 6, and having great difficulties due to transfers and distances, now has 29 active members and is confident of rapid growth in its technologically growing area.

Accomplishments

The apparently simple matter of running a meeting program every month is, in reality, accomplishment enough. For a new club or section, the problem of securing speakers and getting out the membership can be difficult. Some

sections, located in favorable areas with large concentrations of industry, had little trouble. Others were not so fortunate. In **Idaho** the great difficulty getting speakers seriously hampered the development of the section. **Memphis** had success at first, but then found problems because they were forced to depend on local speakers or outside engineers who could pay their own expenses.

But the new sections have not rested their efforts with a good monthly program and a good membership drive. Particularly noticeable is the effort they are making to secure close relations with high schools and colleges and to influence young people to enter chemical engineering. **Coastal Bend** and **Toledo** are both working closely with Texas A&I and the University of Toledo, respectively, to secure accreditation for the chemical engineering departments in those schools. **Memphis, Toledo,** and **Central Pennsylvania** are all offering prizes to outstanding chemical engineering students in local universities and are all actively engaged in programs to encourage high school students to consider chemical engineering as a profession.

The Founders

No local section grows unaided. Hard-working engineers make it grow. Everyone in it is responsible for the success of a section, but as in all things, some men deserve special mention.

Central Pennsylvania: W. E. Keppler, James Lago, Martin Judge, Robert Ghelardi, and Lester Berkowitz.

Coastal Bend: A. E. Howerton, Lewis Gross, Foster Garrison, Henry Dice, and D. C. Lee.

Idaho: L. H. Landrum, C. E. Stoops, T. R. Wilson, Arnold Ayers, D. M. Paige, and D. E. Griffin.

Memphis: Horace Adams, C. W. Dean, T. A. Feazel, N. H. Moore, C. B. Weiss, and D. S. Fritz.

New Haven: W. S. Kaghan, E. L. Borg, J. I. Levitsky, S. Lippa, A. T. Lincoln, R. W. Southworth, W. C. Warner, and S. E. Wilson.

Toledo: J. Scalzo, H. Thober, K. D. Meiser, L. D. Larsen, G. Doyle, A. Kassay, H. Igdaloff, and C. W. Balch.

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(*Continued on page* 106)

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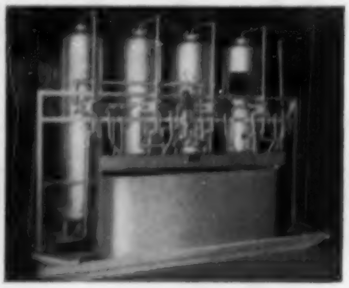

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A.I.Ch.E. **News of the Field**

FROM LOCAL SECTIONS

(*Continued from page* 105)

energy, and . . . there is real reason to hope for peaceful co-existence. . . ."

This was the statement of A.I.Ch.E. President Walt Whitman, speaking on his experience as secretary-general of the Geneva Atoms for Peace Conference, to the September meeting of the **Western Massachusetts Section** (*R. T. Bogan*), and the October meetings of the **East Tennessee Section** (*R. F. Hunt, Jr.*) and the **Nashville Section** (*W. D. Threadgill*). Whitman went on to point out that the successful Geneva Conference proved that technical people from 73 nations can meet harmoniously and usefully, and that they can work very closely on the planning level as long as the subject matter remains scientific.

Still in the nuclear field, the **East Tennessee Section's** September meeting heard J. K. Dillard of Westinghouse Electric describe in detail five of the types of reactors planned or being built under the AEC Five-Year Program. The program is expected to determine the most practical type. While nuclear power is not now competitive with conventional generation methods, it is expected to be in 10 or 15 years.

High and Low

High pressure polyethylene is one of the most spectacular developments in high pressure processing, B. F. Dodge told the September meeting of the **Oklahoma Section** (*L. A. Warzel*). Discussing a field in which he is widely experienced, Dodge reviewed recent developments from high pressure research, changes in physical properties at extreme pressures, and techniques of high pressure research.

Low pressure techniques, in the form of low-pressure pneumatic conveying systems, came in for study at the September meeting of the **Detroit Section** (*R. D. Stevenson*). The speaker, T. Reinauer, Metals Disintegrating Co., Inc., showed that low-pressure conveying is usually in the range 12 cu. ft. of air per pound of material conveyed or less. The typical pneumatic conveying system consists of a pick-up device, piping, receiver or separator, and the exhauster or fan. Advantages of pneumatic conveying were given as: low maintenance, easily cleaned, hygienic, avoids contamination, confines hazardous dusts.

Panel on Gas Products

Gas products plants came under discussion at the September panel meeting

of the **Tulsa Section** (*G. L. Farrar*). Panelists (l. to r. in picture) C. Barry, consulting engineer; J. A. Sutherland, Texas Natural Gasoline Corp.; E. W. Kilgren, Stanolind Oil and Gas Co.; C. R. Childress, Sinclair Refining; and R. L. Rorschach, Warren Petroleum Corp., each discussed a basic aspect of the subject prior to entering the phase of panel discussion. Presentations were made of: 1) developing and negotiating the gas contract; 2) bases of design of gas products plants; 3) petrochemicals from gas products plants; and 4) the future of gas products plants.

Turning from gas to petroleum, M. J. Sterba, Universal Oil Products Co., showed the July meeting of the **Southern California Section** (*R. D. Sheeline*) that changes in premium grade gasoline (from 73 octane in 1930 to 95 octane in 1955, average engine horsepower risen from 75 to 180, average compression ratios gone from 5 to 7.8), coupled with strong competition and increasing refining costs, has forced the refiner to examine critically the existing and available refining processes. Sterba also pointed out that many facilities only recently installed already need modification to avoid obsolescence.

Sound and Taste

Sound waves, particularly ultra-sonic waves, can be used to produce both physical and chemical changes as well as to measure physical properties of various chemicals for control purposes, E. Yeager, Western Reserve Univ., told the September meeting of the **New York Section.** Typical of the physical effects are the production of colloidal suspensions, degassing of liquids, precipitation of aerosols, cleaning of surfaces, and the expediting of mass and thermal transfer in gases and liquids.

Moving from sound to taste, C. G. Harrel, Pillsbury Mills, explained to the June meeting of the **Twin Cities Section** (*E. J. Murray*) that actual taste is by the vapors which are released through chewing and swallowing, the vapors entering the nose through the inner canals. The Government is presently spending many millions of dollars on flavor research in connection with the use of irradiation as a method of preserving food.

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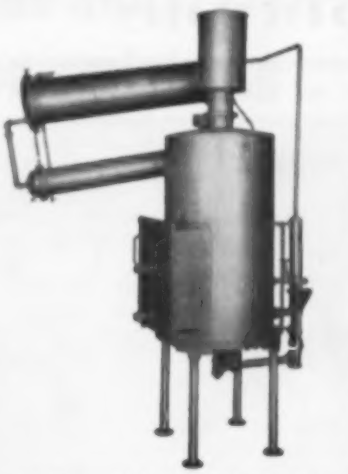

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people

E. W. Bowerman is promoted to assistant division head in the research and development division at Humble Oil & Refining Company's Baytown, Texas refinery. Joining Humble in 1937, he was made section head of R & D in 1946. He holds a patent on alkylation processes and has done development work in isomerization, hydrogenation, and polymerization.

David J. Rex to the newly-created post of process engineer for the silicate detergent calcium division of Diamond Alkali, Cleveland, O.

Morris Beller is assigned to the engineering laboratory of Linde Air Products' Tonawanda, N. Y., laboratories.

J. G. Copeland becomes assistant plant manager at Hercules Powder Company's Parlin, N. J. plant.

Henry L. Coles, head of the department of chemistry and chemical engineering at Michigan Tech., resigns to accept position of general engineer and full time consultant with the Naval Ordance Test Station at China Lake, Calif.

John T. Cumming becomes chairman of the department of chemical engineering and chemistry at Fenn College.

The Foster Grant Company of Leominster, Mass., appoints **Sidney J. Baum** general manager of the petrochemical division. He was recently manager of the Polyco Department, Borden Co.

George F. Polzer is assigned to the newly created position of purchasing director of the Witco Chemical Company, N. Y. In this position he will also coordinate the purchasing of Witco Associated companies. Mr. Polzer was formerly general purchasing agent for chemical raw materials with American Cyanamid Co.

A. A. Bondi is appointed supervisor at the Shell Development Co.'s Emeryville Research Center. He has been with the firm since 1946.

Herman Schneiderman becomes technical director of American Latex Products Corp., Hawthorne, Cal. He was formerly chief of the structural plastics group at Aerojet General Corp., Azusa, Cal.

John F. Ponzek is a new member of the staff of Esso Research and Engineering's design engineering division.

Paul N. Cheremisinoff appointed manager of the Paterson, N. J. plant of the Alsynite Company of America.

Arthur T. Schooley is appointed to the staff of the B. F. Goodrich Company Research Center, Brecksville, Ohio, as a technical man.

Commercial Solvents Corp., N. Y., announces the addition of **Elzie Wolker** and **Quentin R. Jeffries** to the staff. Both men will headquarter at the Terre Haute, Indiana, research and production center.

Howard C. Peterson assumes duties in technical service for phosphate chemicals of Food Machinery and Chemical's Westvaco Mineral Products Div. The commercial development activities of F.M.C.'s Westvaco Chlor-Alkali Division have been moved from N. Y. to South Charleston. There **William B. Rose** directs the consolidated commercial development and research group and **Robert R. Dean** is director of the market section. Also in research and development, **Charles H. Braithwaite** becomes laboratory section director and **Al G. Draeger** takes on duties of director of engineering. **Albert Anson, Jr.,** is F.M.C.'s new manager of consolidated laboratory services.

The Cabot Carbon Company has promoted **N. Dudley Steele** to general production superintendent of carbon black for its Southwestern Division.

Two new chemical engineering additions to the staff of Arthur D. Little, Inc., Boston, are **Dennis E. Johnson,** formerly with Du Pont, and **Walter R. Byrnes,** recent graduate of Worcester Polytechnic Institute.

Henry Schiessl has been appointed technical assistant to the manager of research and development of Industrial Chemical Division, Olin Mathieson Chem. Corp., N. Y.

Francis E. Reese becomes director of engineering of the Plastics Division of Monsanto Chemical Co., Springfield, Mass. Associate director since 1955, he replaces **A. W. Low**, who will become director of overseas manufacture on January 1. **M. O. Debacher** will become manager of overseas plastics manufacture at that time also.

H. K. Eckert, director of manufacturing, takes charge of the plastics division's manufacturing operations at Santa Clara and Long Beach, Calif., and Seattle, Wash., in addition to divisional operations at Texas City, Texas. **Carl E. Pfeifer**, also a director of manufacturing for the division, adds the Saflex plant at Trenton, Mich., to his responsibilities.

C. Howard Adams is appointed manager of plastic product development at Monsanto's research and engineering division, St. Louis.

Also at Monsanto, **Joel O. Hougen** and **Theodore J. Williams** join the engineering department of the research and engineering division. They are in a newly organized section concerned with special research in automatic control of chemical processes. Dr. Hougen has been professor of chemical engineering at Rensselaer Polytechnic Institute since 1948, and Dr. Williams, assistant professor of chemical engineering at the U. S. Air Force Institute of Technology, Wright Patterson Air Force Base, Ohio.

Will C. Schroeder, professor of chemical engineering, U. of Maryland, will be one of the speakers at the first annual Energy Resources Conference to be held in Denver, October 29 through 31.

RECENT CHEMICAL ENGINEERING GRADUATES ENTER INDUSTRY

Stuart Nussbaum and **Robert DiNapoli** to the Tonawanda, New York Laboratories of Linde Air Products; **Fred Davenport** to the Richmond California plant of Stauffer Chemical; and **Robert F. T. Sterbenz** to The B. F. Goodrich Company Research Center, Brecksville, Ohio.

A number of recent chemical engineering graduates also joined Esso Research and Engineering at Linden, N. J. **Frederick H. Peper** and **Carl E. Heath, Jr.**, assigned to process research; **Joseph L. Fellin** and **Robert M. Miller** with products research; **Charles Roming, Jr.**, and **C. Robert Landgren** to chemicals development; **Philip Zaybekian** assigned to the economics division; and **Gilbert R. Gervasi** and **Richard I. Bergman** with the design division.

(*Continued on page* 118)

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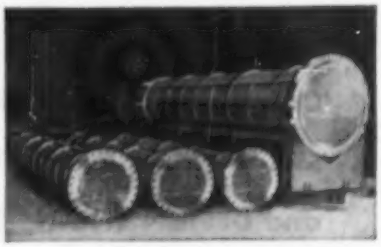

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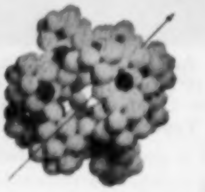

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located in a progressive mid-western city contact us at once, in strictest confidence, supplying full résumé of experience, personal data, and salary desired.

Moving allowance and competent assistance to your family in getting settled. Interviews arranged promptly.

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A FAST GROWING, FAST MOVING ENTERPRISE

opportunities for

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PHYSICISTS

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MECHANICAL ENGINEERS

and DESIGN ENGINEERS

TEXTILE ENGINEERS

PRODUCTION ENGINEERS

Rapid growth of synthetic fiber development creates unlimited opportunities for technical men who want to be on the forefront of this exciting field. Openings now in fiber process development, mechanical development, products development, and production.

Men with 0-15 years' experience in their profession will be considered.

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Send résumé to:

Textile Fibers Department
CARBIDE AND CARBON CHEMICALS COMPANY
P. O. Box "N"
South Charleston, West Virginia
Attention: **W. H. Billings, Jr.**

New York Personnel Dept. T.
CARBIDE AND CARBON CHEMICALS COMPANY
30 East 42nd Street
New York 17, New York
Attention: **Mr. E. R. Brown**

DU PONT NOW OFFERS

SIX CAREER POSITIONS OF CHALLENGE AND RESPONSIBILITY FOR SPECIALIZED CHEMICAL ENGINEERS

The Engineering Service Division of du Pont's Engineering Department provides consulting service and technical assistance to production, maintenance, design, research, and constructive groups within the company. The Division's objectives are to assist other company units in improving plant efficiency and product quality, in reducing investment and operating costs, and in increasing capacity.

Six openings are immediately available for experienced graduate engineers to provide consulting service to operating plants in the following specialized chemical engineering fields:

WATER

The desirable background will include extensive experience in water procurement and treatment for industrial plants. Knowledge of water treatment plant operation through practical experience is important. The successful applicant will provide engineering advice to those designing, constructing, and operating company plants on problems involved in the procurement and treatment of industrial water supplies.

PLASTICS APPLICATION ENGINEER

A graduate engineer who is qualified by education and experience to assume responsibility in providing consulting service in the fields of plastics utilization and corrosion barriers used in the construction of chemical processing equipment and facilities. Duties will include: the initiation and direction of studies to insure optimum use of these materials and to determine property data requirements for engineering applications; and the development of specifications for procurement, design, construction, maintenance, and utilization.

PETROCHEMICAL PROCESS & EQUIPMENT

Successful applicant will analyse existing and proposed chemical processes for utilisation of petroleum processing equipment and methods for obtaining greater yield and lower equipment investment, particularly with respect to hydrocarbon processes. Typical operations to be evaluated include solid fluidisation, adsorption, reforming, and catalysts. This requires broad familiarity with equipment such as hypersorbers distillation columns, cracking furnaces, low temperature refrigeration systems, and compressors. Other duties include trouble-shooting, and economic evaluation of alternative processes and equipment.

STATISTICIAN ENGINEER

Duties include: statistical design and analysis of experiments; application of probability theory and statistical inference to production and management problems, ranging, as examples, from sales forecasting for production and inventory control to use of probability in setting optimum plant maintenance policies; and Operations Research—the mathematical and statistical formulation of production, marketing, and financial control problems prior to analysis by data processing systems. Operations are on a company-wide basis. Desired qualifications: a Ph.D. or equivalent in mathematical statistics or physical science (including engineering), with experience with and interest in practical design of experiment, mathematical statistics, or probability theory.

AGITATION AND MIXING EQUIPMENT

The most desirable qualifications will include five years of industrial experience, preferably in fluid mechanics, with broad knowledge of both theory and practice in the field of agitation and mixing. Duties will include: determinations of agitation requirements for chemical reaction, heat and mass transfer, dispersion, blending and other operations; equipment evaluation; selection, specification, and design; modification of existing equipment for unusual or special agitation problems; trouble-shooting; and start-up assistance.

MATERIALS HANDLING

Graduate engineer with three to ten years' experience with bulk or package handling systems and equipment. The successful applicant will be expected to have engineering knowledge of belt conveyors, bucket elevators, screw conveyors, storage bins, chutes, hoppers, and feeders. Familiarity with pneumatic conveyors or mobile handling equipment is desirable. Duties include providing consultation on existing equipment, selection of new equipment, and the development and execution of major materials handling engineering programs.

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To arrange an appointment with our technical representative, please call
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PEnnsylvania 6-5096

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Sun-Mon-Tues-Wed
December 9-10-11-12
To arrange an appointment with our technical representative, please call
Mr. K. S. Marlin, Jr.
HAncock 6-2044

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...THROUGH CHEMISTRY

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E. I. du Pont de Nemours & Co., Inc.

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Help develop the world's first nuclear powered fleet

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At the country's largest design-engineering center for nuclear power reactors, Bettis Plant in Pittsburgh, operated for the Atomic Energy Commission by Westinghouse, the application of nuclear power has progressed rapidly. However, the nuclear power plants already in operation today represent only the beginning of a new technological era. *Major advances in many areas are necessary.*

These include: work in the fields of plant design, instrumentation, thermal analysis, process or corrosion; experimental or theoretical investigations in heat transfer under both steady state and transient conditions; work with corrosion, particularly with metals in contact with high temperature, high pressure water; design of heat exchangers, pressure vessels . . . to meet the new and severe requirements.

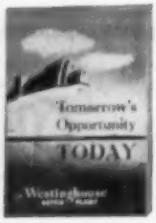
To do this, Bettis Plant needs farsighted men. Regardless of your interest, you can choose a place in the varied operations at Bettis Plant.

Atomic experience is not necessary.

What's more, Bettis Plant is in Pittsburgh's South Hills. Here you can enjoy good living in pleasant suburbs near the plant, and still be convenient to one of the nation's most progressive metropolitan areas.

Educational opportunities are exceptional. Westinghouse helps you continue your studies at any one of three Pittsburgh universities.

Write for descriptive brochure on opportunities in your field. Be sure to specify your interests. Address Mr. A. M. Johnston, Westinghouse Bettis Plant, Dept. A75, P.O. Box 1468, Pittsburgh 30, Pa.



BETTIS PLANT

Westinghouse

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Assignments will cover the application of processes to a wide variety of industrial plants, ranging from complete integrated refineries and chemical processing centers through all types of individual process units. The work includes coordination of chemical engineering, the selection and design of process equipment and machinery, and startup of completed plants.

Top salaries, fine facilities, profit-sharing retirement plan. Write to the head of our Personnel Department, Mr F B Stratford.

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Engineers
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A progressive and nationally known chemical company located in Central Illinois offers challenging and permanent positions with excellent growth potential for Chemical Engineers having two to six years' applicable experience. Products are Liquid Hydrocarbons, Ethylene, Ethyl Alcohol, Ethyl Chloride, and Polyethylene.

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J. H. Strange
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American Viscose Corporation, a chemical-process industry, has some **permanent** positions open now for **chemical engineers**. To qualify you need a B.S. or M.S. degree from a recognized institution, and, preferably, 3-5 years of experience in process **development**, product-improvement studies, or chemical engineering 'trouble-shooting' for manufacturing.

The location is in suburban Philadelphia (Marcus Hook) at the **Research and Development Division**, or at one of our seven plants in Pennsylvania, West Virginia, and Virginia.

AVISCO

These openings are technically challenging and offer good advancement opportunities. Interested candidates are invited to submit résumés of personal data, educational history, and work experience to:

Personnel Recruitment Department
AMERICAN VISCOSE CORPORATION
1617 Pennsylvania Boulevard
Philadelphia 3, Pennsylvania

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Immediate opening with good growth potential for Chief Design Engineer to supervise Chemical Plant mechanical design operations. Must have a minimum of 10 years' experience in design or process engineering for Chemical Process industries. Applicant up to 55 years of age accepted.

Work with Pittsburgh Coke & Chemical Company, a comparatively young company, still small enough to quickly recognize and reward individual initiative and ability.

If you are a graduate engineer having the above mentioned qualifications, write or call immediately:

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Pittsburgh Coke & Chemical Company

Neville Island
Pittsburgh 25, Pa.
Spalding 1-4400

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We have excellent openings for **CHEMICAL ENGINEERS** in projects associated with the production and distribution of oxygen, nitrogen and argon as low temperature liquids or gases.

LOCATION: Our Tonawanda Laboratories in suburban Buffalo, New York—our largest research and development facilities.

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CHEMICAL ENGINEERS NEEDED

Career openings available in long range expansion program. Work involves process planning, economics, design, and occasional field follow-up.

Prefer men of high scholastic rating and with one to seven years' experience. There are also a number of openings for very recent graduates. Both Bachelors and Masters degree positions are available. Salary commensurate with experience and qualifications.

If you are interested in an opportunity for growth and promotion with a leader in the petroleum industry, write today giving full details of education, experience, salary desired, availability date and references.

All inquiries will be considered promptly and held confidential.

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Esso Research Center
Employee Relations-C
P.O. Box 51 **Linden, N. J.**

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Celanese's increasing interest in Plastics Research and Development has created a highly responsible and rewarding position for a Chemical Engineer with a master's degree and 2 to 5 years experience, or the equivalent in industrial experience.

The man selected will be responsible for the supervision and planning of pilot plant operations; preparation of pilot plant designs, and of preliminary plant designs; and for the start up operations in production units. Along with a good salary and liberal benefits, he will have the satisfaction of seeing his projects through from inception to completion . . . and the opportunity for advancement within the vast structure of the Celanese organization. All inquiries in confidence. Please send resumes, including salary desired, to G. M. Hewitt.

Celanese

CORP. OF AMERICA
Morris Court **Summit, N. J.**

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A chemical or mechanical engineer with at least five years' industrial experience, to analyze technological, economic and procedural problems in the manufacture of pulp and paper. An opportunity for significant achievement. Salary open. Apply to Personnel Dept., West Virginia Pulp and Paper Company, 230 Park Avenue, New York 17, N. Y.

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B.S. or M.S. in Chemistry, Chemical Engineering or Petroleum Engineering, for basic and applied research in Corrosion. Prefer man with experience in oil field corrosion work or analysis, treatment and handling of oil field brines. Permanent position in rapidly expanding research organization located in Pacific Northwest, excellent benefits, good working conditions. Salary dependent on qualifications.

Reply to: Dr. T. R. Pritchett
Kaiser Aluminum & Chemical Corp.
Dept. of Metallurgical Research
Spokane 69, Washington

PROCESS ENGINEERS
With three to six years experience

Several qualified process engineers can broaden their professional responsibilities in our Process Engineering Department. They will design a wide variety of plants for petroleum refining and large volume petrochemical processing.

Assignments range from complete integrated refineries and chemical plants through all types of individual process units. The work includes heat and material balances, and computations for unit operations such as fractionation, heat-transfer, absorption and extraction.

Fine facilities, top salaries, new retirement plan. Write to the head of our Personnel Department, Mr F B Stratford.

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Advertisements in the Classified Section of Chemical Engineering Progress are payable in advance at 20¢ a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section of Chemical Engineering Progress agree that all communications will be acknowledged; the service is made available on that condition. Boxed advertisements are available at $17 a column inch. Size of type may be specified by advertiser. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 15th of the month preceding publication.

ENGINEER
HIGH TEMPERATURE METALLURGY AND CORROSION RESEARCH ON NUCLEAR FLIGHT PROJECT

This senior research position in the application of nuclear energy to the field of flight calls for both versatility and breadth of creative thinking. Every bit of the talent that the qualified engineer brings to this position will be effectively employed in research designed to provide improved metals and alloys for use in an aircraft nuclear power plant.

The job requires a degree in physical metallurgy or metallurgical engineering and 8 to 10 years experience in working with high temperature or corrosion resistant metals and alloys. (If directly related, time spent on obtaining an advanced degree may be considered part of the experience.)

Publication of research results in the appropriate classified or open literature is encouraged.

OPENINGS IN CINCINNATI, OHIO AND IDAHO FALLS, IDAHO

Address replies in confidence, stating salary requirements, to location you prefer

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Cincinnati, O.	Idaho Falls, Idaho

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There are outstanding career opportunities with one of the 100 largest corporations in the United States for men with the following qualifications:

- **One to five years experience in petroleum refining or related activities.**
- **B.S. or higher degree and experience in development, pilot plant operation, process design, process trouble shooting, refinery process engineering, economic studies or related work.**
- **Age range . . . 22-32.**

Choice positions open in Cleveland, Toledo and Lima, Ohio.

Write, giving a complete resume of your education, experience and personal data to:

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1737-C Midland Building, Cleveland 15, Ohio

There's a bright future waiting for the right men with

THE STANDARD OIL COMPANY (OHIO)

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NEW YORK
OR
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Offers immediate long range opportunities for

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Process or project experience in refinery, petrochemical or chemical fields.

Liberal relocation allowances for you and your family.

Send Résumé to
Manager of Employment & Placement
Industrial Relations Division

For an immediate personal interview you may phone:

Paul Keating, Plaza 7-4400, New York City
Joe Braddick, Fairfax 3-2401, Houston, Texas
Bill Milligan, Tucker 1549, Los Angeles, Calif.
Don Palmer, Douglas 2-4032, San Francisco, Calif.

BECHTEL CORPORATION
220 BUSH STREET San Francisco 4, Calif.

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AMOCO

PROFESSIONAL CAREER OPPORTUNITIES

Major oil company with plants located in Texas, Virginia, Arkansas, and Louisiana. Major Research and Development activities located in Texas City, Texas.

CHEMICAL ENGINEERS

required for process design, process development and technical service to refining and chemicals manufacture. BS, MS, PhD, 0-10 years' experience.

Send résumé to
Administrative Director
Research & Development Dept.
AMERICAN OIL COMPANY
Texas City, Texas

Heat Exchanger ENGINEERS

BRAUN

- *Offers*
  Responsible positions with the outstanding manufacturer of heat exchangers.
- *Needs*
  Men with refinery or chemical plant experience.
- *Prefers*
  Men familiar with process design and estimating of heat exchangers, fractionation columns, and other pressure vessels.

Send resumé to
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1000 SOUTH FREMONT ALHAMBRA, CALIFORNIA

Research Engineers

Unusual opportunity to do stimulating work in Chemical Engineering or Reactor Technology on pilot plant or laboratory scale. Several years' experience desirable in reactor water technology, reactor economics, or radiochemical techniques. Opportunities to direct projects or work under experienced men. These are permanent positions offering professional and personal growth. Please send résumé to:

Mr. J. A. Metzger
ARMOUR RESEARCH FOUNDATION
of
Illinois Institute of Technology
10 West 35th Street
Chicago, Illinois

CHEMICAL ENGINEERS

Major Oil Company has openings for Chemical Engineers in several phases of process engineering. Locations near New Orleans and south Arkansas. Attractive salary and benefits program.

In reply give age, education, experience and salary expected.

PAN AM SOUTHERN CORPORATION

P. O. Box 2,

New Orleans 6, Louisiana

Chemical Engineers

Project Management

Sales Engineering

A well-known, aggressive engineering firm in downtown Cincinnati with an impressive record in designing and building plants for diffusional process operations and organic synthesis has an opening of major responsibility in each of the above classifications. Our work and medium size require each man to handle broad-range engineering assignments and a high level of personal responsibility—with distinct opportunities for individual recognition. These are good positions with good salaries for the right men. In addition, Cincinnati is a pleasant place to live; progressive, modern, friendly and offering many activities. Send data and salary to Personnel Director.

VULCAN ENGINEERING DIV.
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IMPORTANT MANAGEMENT and TECHNICAL OPPORTUNITIES

Openings with stable and expanding oil companies in agreeable locations offering unusual, immediate and long range prospects for responsibility, recognition, scope of work and compensation.

Petroleum Refinery Management

There are two openings for operating head and assistant operating head respectively of two refineries in the 25-50,000 bbl. range. Employment conditions are most attractive.

Operating Supervision

There are two openings for departmental operating supervision. Experience in catalytic cracking essential, preferably also other catalytic processing and usual distillation, blending, organization, etc.

Engineers

Three chemical engineers with acceptable refinery processing experience generally capable of eventual advancement to supervision in operation, organization and management. Petro-chemical experience desirable. One of these with engineering company.

One mechanical or civil engineer qualified refinery maintenance supervision with good practical background this field.

Safety

Supervisor, either graduate or ex-operator, experienced in refinery or chemical plant safety.

These positions offer outstanding career opportunities in the petroleum industry for those selected. Our clients will require men of proven capabilities and having qualities necessary for advancement. We are continually seeking upper level personnel for clients. All replies are confidential and no obligations are incurred by applicants.

For Particulars Write to ROBERT C. SPEARS

GEORGE ARMISTEAD and COMPANY

Engineers and Consultants 1200 18th Street, N.W., Washington, D. C.

PROCESS ENGINEERS with Eight or More Years Experience

Our Process Engineering Department has opportunities for several experienced engineers who wish to follow their preferred fields in petroleum refining or large volume petrochemical processing.

Assignments will be primarily process design and economics – determination of overall process requirements, selection of processing steps, and economic evaluation of processes. Other work may include market analysis, industrial surveys, and technical assistance to sales.

Write to the head of our Personnel Department, Mr F B Stratford.

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PHYSICAL CHEMIST CHEMICAL ENGINEER

Product development work. Background in paper chemistry helpful, although not necessary. 0-5 years' experience. Location near Boston. Please send resume to Industrial Relations Department:

Dewey and Almy Chemical Company
(Division of W. R. Grace & Co.)
62 Whittemore Avenue
Cambridge 40, Massachusetts

CHEMICAL ENGINEER

Chemical company, manufacturing organic pesticides, offers opportunity to obtain diversified chemical engineering experience to chemical engineering graduate with 2-5 years' experience in pilot plant or organic chemical production plant—Kansas City, Missouri location.

CHEMAGRO CORP.
8819 St. John Ave.
Kansas City, Missouri

Petro-Chemical Sales Engineer

A nationally known engineering and construction firm has an opening for a Petro-Chemical Engineer in their Houston Sales Office. Under 50 years of age. Familiar with Gulf Coast area. Chief Engineer or Project Engineer caliber, thoroughly familiar with oil processes and cost analysis. He should be able to coordinate project requirements, effectively preside at conferences with clients and know basic principles of design. Substantial salary with splendid opportunities. Write in confidence evaluating your experience in relation to our requirements Box 4-10

(*Continued on page* 118)

USE CEP for Progress in Obtaining the Best Chemical Engineers

SITUATIONS WANTED
A.I.Ch.E. Members

SALES—Seasoned chemical engineer desires opportunity in sales. Ten year record of accomplishment in applied research, process development, administration, management, chemical and ordnance industries. Good combination of engineering "know how," personality and ability to sell ideas. Prefer connection with manufacturer or contractor selling chemicals, process equipment and/or complete plants, or research and development services. B.Ch.E., age 31. Box 1-10.

CHEMICAL ENGINEER—Age 31. Seeking challenging position in marketing or administration. Two years' experience research and development, five years' technical sales and promotion of process equipment and specialties. Box 2-10.

SALES MANAGEMENT—Ten years' successful sales engineering and instrument application to the chemical industry. Other experience five years' production supervision of petrochemicals. Desire sales management work for company vending equipment to chemical, nuclear, or metallurgical industries. Box 3-10.

SAVE THOSE BACK ISSUES

Every so often an unprecedented demand for a particular issue, or an unexpected influx of new subscribers and members puts the editor in the embarrassing position of running out of copies of Chemical Engineering Progress. This has happened several times in our short history and if members have copies of any of the following issues, we would be glad to purchase them. The issues which we need and for which we will pay 75 cents each are: July, Aug., Oct., Nov., 1950; Nov., 1952; Feb., 1953; May, Dec., 1954; Jan., May, 1955; Jan., Mar., 1956.

All these issues were overprinted to a great extent, but because of features and other demands, single copy sales, etc., they were completely exhausted in a short time.

YOUR CHANGE OF ADDRESS

National headquarters of A.I.Ch.E. is concerned about nondelivery of copies of *Chemical Engineering Progress* to members and subscribers. We therefore urgently request you to notify us promptly regarding your change of address. Allow 60 days for such change.

people

The appointment of **J. Ray Coulter** as manager of manufacturing for the agricultural chemicals division is announced by American Cyanamid, N. Y.

Stepan Chemical of Chicago announces that **D. H. Francis** is made director of engineering and member of the firm's executive committee.

John S. Wilson, director of executive development of the Corn Products Refining Company, has become an associate of Heidrick and Struggles, executive recruiters. An alumnus of Indiana University, where he was awarded B.S. and M.A. degrees in 1938 and 1939, Mr. Wilson has been associated with Corn Products since his graduation.

The Board of Directors of W. R. Grace & Co., N. Y., elects **Marlin G. Geiger** an executive vice president in charge of the chemical group, composed of the firm's seven chemical divisions.

R. L. Logan is made manager of the Niagara Falls electrochemical plant of the Potash Division, International Minerals & Chemical Corp.

L. P. Skinner, Jr., announces the opening of Process Sales Company, P. O. Box 1, Beaumont, Texas, a new engineering and sales agency for manufacturers of industrial instrumentation and chemical process equipment.

W. L. Kleiber named manager of the Rochester, N. Y., plant of the Industrial Chemicals Division, Olin Mathieson Chemical Corp.

James B. Kaye rejoins The Dow Chemical Co. as process development engineer in the Ludington, Michigan, plant.

Hercules Powder appoints **Lyle W. Rothenberger** manager and **Lewis M. Kieffer** plant superintendent of the Gibbstown, N. J. Plant. **Paul E. Graybeal** becomes assistant plant superintendent at the Hattiesburg, Miss. plant and **John E. Greer** is appointed works manager of the Pluto Works, Ishpeming, Michigan.

Promotion of **Blaine F. Jaeger** to assistant manager of staff laboratories, engineering department, is announced by Minnesota Mining and Manufacturing.

Carroll A. Hochwalt, vice president of R & D at Monsanto, St. Louis, is winner of the 1956 Midwest Award of the A.C.S. for industrial research leadership.

the chemical engineer in MARKETING

John T. Dunn heads the butyl sales service organization of Thiokol Chemical Corp., Trenton, N. J.

The new cellulose products office of Hercules Powder, Chicago, comes under the direction of **Robert R. Stover,** technical sales representative.

John C. Jacobsen becomes a sales representative for Monsanto Chemical's inorganic chemicals division, district sales office at Cincinnati.

Walter Messner, of the Bristol Company, becomes manager of the firm's St. Louis office.

B. W. Graham joins the Armour Chemical Division, Chicago, Illinois, as director of sales.

Burton W. Graham becomes sales director of the chemical division of Armour and Company, Chicago. He was formerly with the Davison Chemical Division of W. R. Grace, where he was director of commercial development. Mr. Graham received a Master of Science degree from the University of Florida.

John R. Ryan named assistant director of sales in the explosives department of Hercules Powder, Wilmington.

The Ralph M. Parsons Co., Los Angeles, announces the appointment of **John E. McKay** to its business development staff. He brings to this position a background of 14 years with the Fluor Corp.

Robert F. Husband is promoted to associate professor of pulp and paper technology at the State University College of Forestry at Syracuse University.

Richard T. Yates, manager of the agricultural chemicals division, naval stores department of Hercules Powder, is given a special assignment to investigate new fields of chemistry in which the company is interested.

Commercial Solvents Corp., N. Y., promotes **Olin M. Herner** to chemical engineer.

Raymond E. Fiedler joins the staff of Archer-Daniels-Midland, Minneapolis, as manager of agricultural products development.

Directors of Eastman Kodak elect **Clarence L. A. Wynd** a vice president. Mr. Wynd is assistant general manager of the Kodak Park Works.

Necrology

Frank Homer Bell, 59, southern sales representative and field export sales manager of the Philadelphia Quartz Co.

James J. Kerrigan, 62, chairman of the executive committee of the board of directors of Merck & Co., Rahway, N. J.

George Taber, Jr., 66, consulting engineer.

Announcement is made of the appointment of **Ernest J. Hill** as sales manager of Colton Chemical Co., Cleveland, a division of Air Reduction.

M. A. Bigelow assumes duties as assistant sales manager, Ucon products, for Carbide and Carbon Chemicals, N. Y. With the firm since 1944, Mr. Bigelow was appointed a territory field manager for the special products department last year.

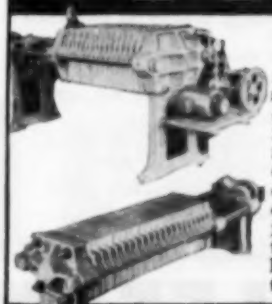
Harry W. Buchanan, III, named sales manager of chemicals, metals and plating products at Metal & Thermit, N. Y. In 1955, as sales manager of the chemical division, he was granted a leave of absence for one year to accept a Sloan Fellowship for advanced study at M.I.T.

F. W. Hanson appointed Houston district sales engineer for Electro Metallurgical Company, a division of Union Carbide and Carbon.

SPERRY

As pioneers in the filter press field, and one of the oldest and foremost manufacturers of filtration equipment, D. R. SPERRY & CO. is well qualified to evaluate your specific filtration requirements.
Sperry *Research* has categorically filed over 60 years filtration experience from continuous field reports and laboratory tests. Sperry *Engineering* applies filtration's most advanced thinking in the development of new products and new methods for obtaining better filtration at lower cost.
Working side-by-side, Sperry *Research* and Sperry *Engineering* offer today's best source of information and equipment for tomorrow's production needs.

FILTER



A complete range of styles and sizes . . . standard or special . . . for every filtration need. With center, side, or corner feed; open or closed delivery; simple or thorough washing; jacketed plates for filtering at controlled high or low temperatures.

PRESSES

SPERRY FILTER BASES

All types . . . all sizes. Plain or punched to your specifications. Besides cotton and paper, bases are furnished in wool, synthetics, glass and woven metals.

SPERRY Closing Devices

Sperry offers the widest range of Closing Devices to match your filter design needs. Each engineered in its own way to speed production, insure safety, save labor, and increase the life of the filter cloths. Choose from nine popular models—including the new easy-to-install HANDRAULIC and the popular EHC-L Electric Closing Device—factory installed on new Sperry Filter Presses or field installed in existing presses of any make.

New Handraulic Closing Device

Send for SPERRY CATALOG

Complete with charts, tables, and diagrams to help in the operation, maintenance and selection of filtration equipment. Write for your free copy of Catalog 7-E today.

We'll see you in Cleveland
Nov. 27-30
Booth 296

D. R. SPERRY & CO.
BATAVIA, ILLINOIS

Sales Representatives

George S. Tarbox
808 Nepperhan Ave.
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B. M. Pilhashy
833 Merchants Exchange Building
San Francisco 4, California

Alldredge & McCabe
847 E. 17th Avenue
Denver 18, Colorado

Texas Chemical Engineering Co.
4101 San Jacinto
Houston 4, Texas

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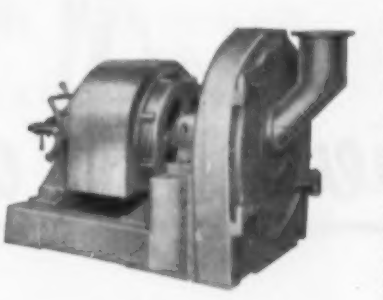

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news and notes of A.I.Ch.E.

Council at Pittsburgh sat for well over 16 hours on Saturday & Sunday, September 8 & 9, chewing over A.I.Ch.E. problems & policy decisions . . . As predicted here last month, practically a complete day was spent on the new engineering center alone . . . A.I.Ch.E. went as far as it legally could in accepting the special Task Committee report on housing of the Engineers . . . In essence, it voted approval of three of the five recommendations in the report: (1) that the center be in New York, (2) that the present center be rebuilt if practical, otherwise another New York site be sought, (5) that plans for building be made with optimism about future growth . . . A.I.Ch.E. favors items 3 and 4, but since we are not yet members of United Engineers Trustees, and since the resolution called for action by U.E.T., Council felt that it could not legally approve these items, namely, that U.E.T. be authorized to include A.I.Ch.E. **when properly qualified** and that U.E.T. be authorized to raise money, accept contributions, let contracts for building, etc. . . . Point of negotiation is, of course, what A.I.Ch.E. has to do to join U.E.T. (see column last month) . . . Council then appointed a Negotiating Committee, composed of T. H. Chilton, chairman, L. C. Kemp, R. P. Kite, E. P. Stevenson, & B. F. Dodge, to work with U.E.T. on A.I.Ch.E. qualifications (Executive Committee meeting of August 20) . . . Full report to the membership will undoubtedly be made at the business meeting at Boston on December 10.

Nuclear Congress, to be held March 11-15, 1957, in Philadelphia, finds A.I.Ch.E. again cooperating in this field . . . Convention Hall has been reserved for the Atomic Exposition and Congress, and advance indications already show that this will be a much larger affair than the one held last year in Cleveland . . . In addition to the nuclear papers presented by the many societies who are again cooperating in supplying a week's technical program, the Congress, which is under the guidance of the five engineering societies, will also have a management conference, sponsored by the National Industrial Conference Board, and a Hot Labs Conference . . . This is a four-pronged avenue into the nuclear area by the engineering and management groups and promises to be the big and important event in the nuclear field each year.

Education Projects Committee. The Chemical Engineering Education Projects Committee, under Bob Kintner, has turned in an interesting report on what it has been doing . . . we have extra copies, so if you are interested, write . . . covers such things as the new format and expansion of the Chemical Engineering Problems booklet . . . the next edition of the Chemical Engineering Faculties list, which Professor K. A. Kobe is spark-plugging again & which has come to be looked upon as a standard work in the field . . . the new Chemical Engineering Educational Films list . . . plus other items on Industry-sponsored Schools for Teachers, Course Surveys, Booklist, etc. . . . This is one of the hardest working committees of the Institute and the good it accomplishes year after year is amazing.

Student Chapter News. Student Chapter News, a feature A.I.Ch.E. service to students for many years, is about to lose its editor . . . Professor Knudsen of Oregon State College has become busy with the Seattle Meeting (next June) and is reluctantly withdrawing as editor . . . Jim has done a terrific job over these past 4 years and the Institute and countless numbers of students owe him a great deal.

American Sanitary Engineering Intersociety Board has asked A.I.Ch.E. to join with American Public Health Association, American Society of Civil Engineers, American Society for Engineering Education, American Water Works Association, & Federation of Sewage and Industrial Wastes Association to certify licensed engineers in the field of sanitation. This was approved by Council.

Entrance Fees of Student Members who transfer to associate membership in the year they graduate have been waived by Council . . . This recommendation was made by a special Study Committee (see this column for March, 1956) & was concurred in by the Membership Committee.

A Public Relations Counsel has been hired to aid in the publicity for the Boston Meeting.

New Election Ballot approved by Executive Committee will have numbers alongside candidate names for I.B.M. tabulation . . . will be mailed to members around October 15.

F.J.V.A.

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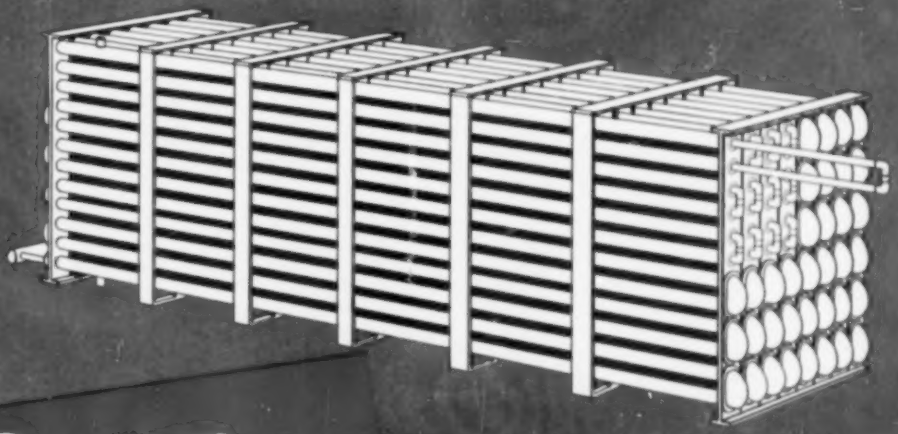

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